US005815820A

United States Patent [19]

Kiem et al.

[11] Patent Number: 5,815,820

[45] Date of Patent: Sep. 29, 1998

[54] **TRANSMITTER HAVING ADJUSTABLE POWER LEVELS RESPONSIVE TO THE POSITION OF A MOVABLE ANTENNA**

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[73] Assignee: **Motorola, Inc.**, Schaumburg, Ill.

[21] Appl. No.: **880,918**

[22] Filed: **May 11, 1992**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 729,502, Jul. 12, 1991.

[51] **Int. Cl.**[6] **H04B 1/38**

[52] **U.S. Cl.** **455/575**; 455/90; 343/702

[58] **Field of Search** 455/89, 90, 82, 455/83, 126, 128, 129, 127; 343/702, 901

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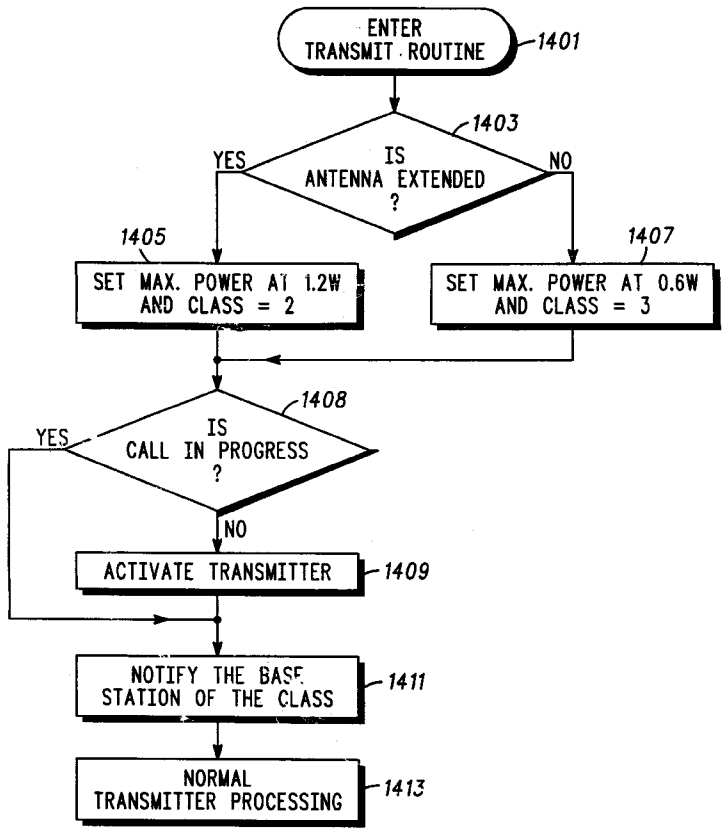
Primary Examiner—Edward F. Urban

Attorney, Agent, or Firm—Kevin D. Kaschke

[57] **ABSTRACT**

A portable radiotelephone (**200**) adjusts its transmit power responsive to the position of a movable antenna (**213**). The antenna (**213**) is movable between a retracted (**313**) and an extended position (**314**). The portable radiotelephone (**200**) transmits at low power when the antenna (**213**) is retracted and at high power when the antenna (**213**) is extended. Additionally, the portable radiotelephone (**200**) can notify a remote base station of the change in transmit power at any time during transmission.

22 Claims, 13 Drawing Sheets



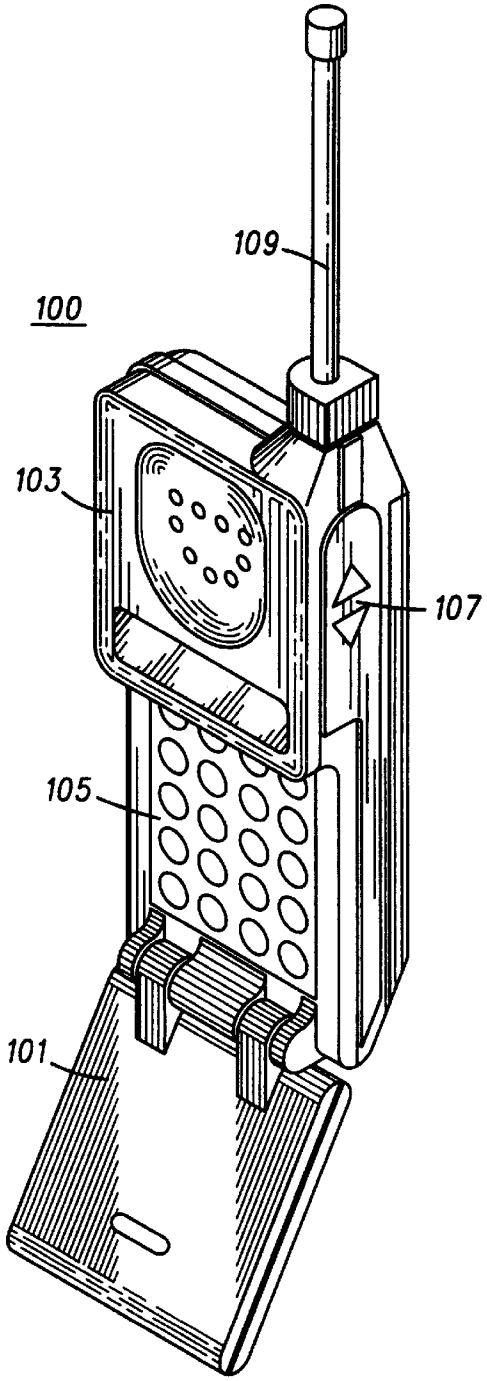


FIG. 1

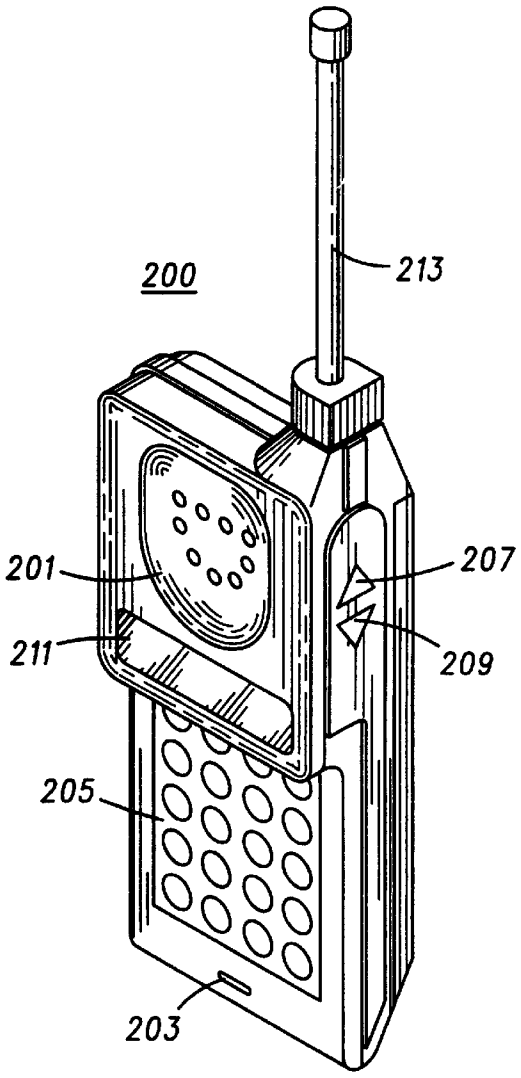


FIG. 2

FIG. 3A

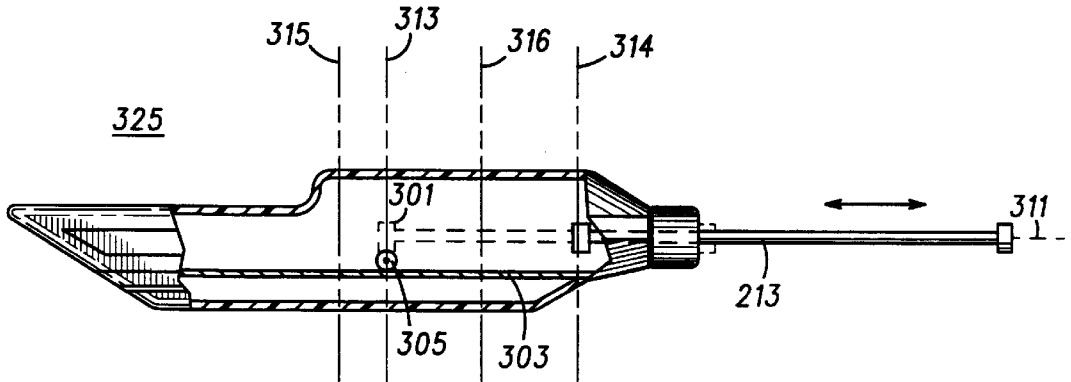


FIG. 3B

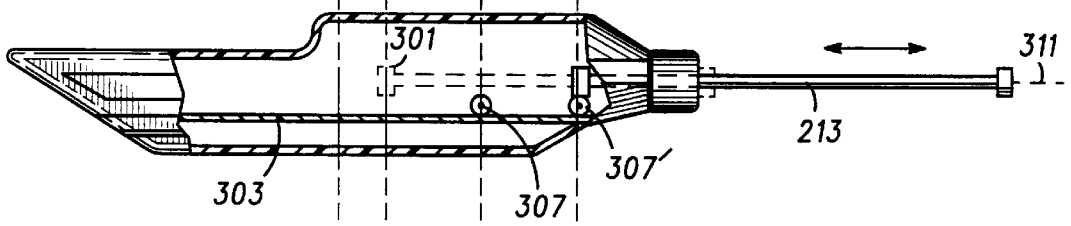
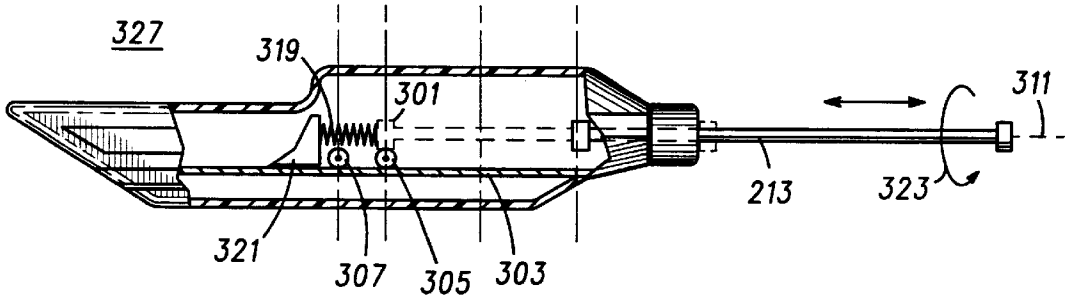


FIG. 3C



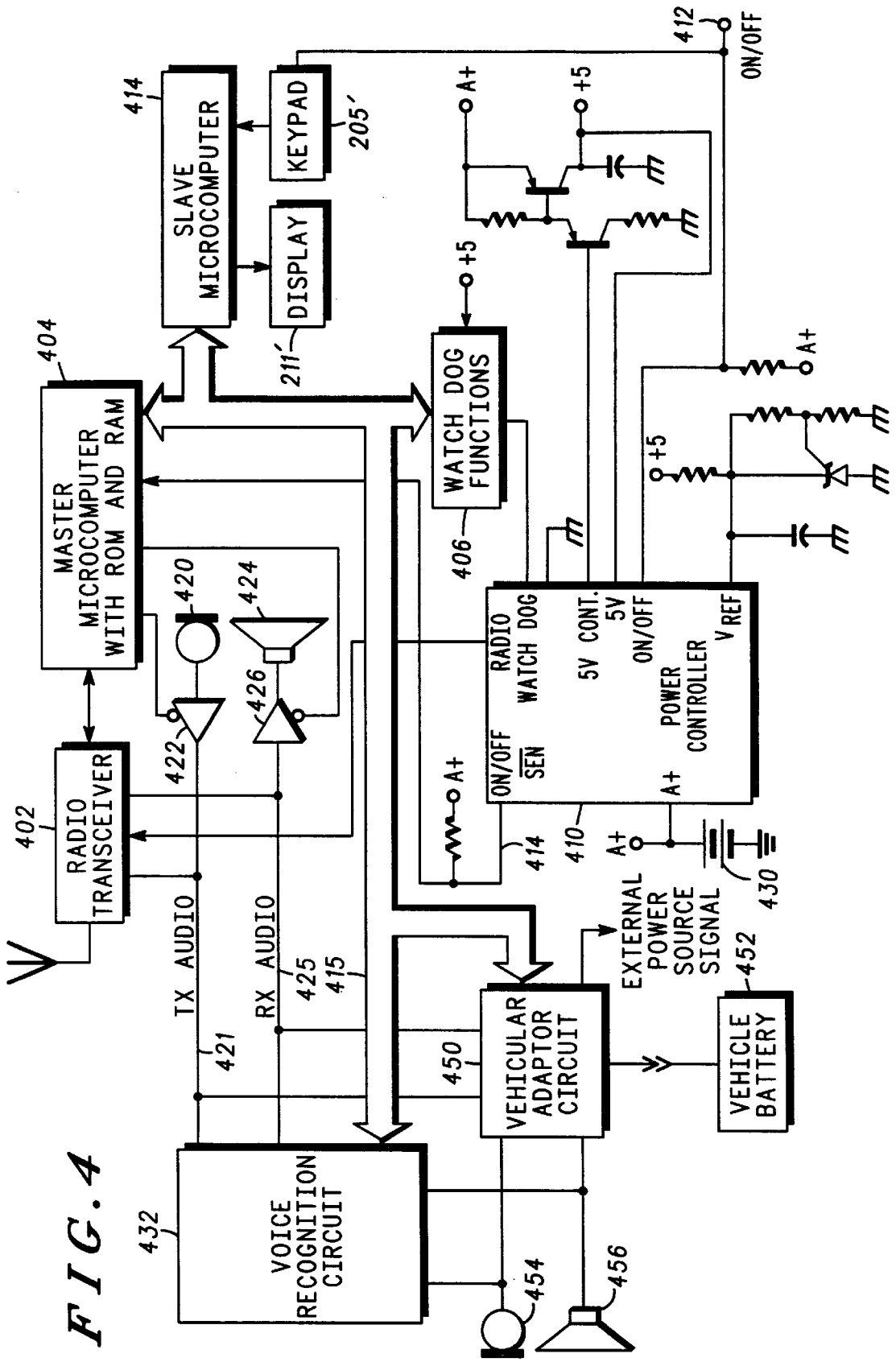

SLAVE MICROCOMPUTER
414
KEYPAD
205'
DISPLAY
211'
MASTER MICROCOMPUTER WITH ROM AND RAM
404
WATCH DOG FUNCTIONS
406
RADIO TRANSCEIVER
402
420
422
424
426
RADIO WATCH DOG
5V CONT.
5V ON/OFF
V REF
ON/OFF
SEN
POWER CONTROLLER
410
414
A+
+5
412
ON/OFF
TX AUDIO
RX AUDIO
421
425
415
VEHICULAR ADAPTOR CIRCUIT
450
EXTERNAL POWER SOURCE SIGNAL
452
VEHICLE BATTERY
430
VOICE RECOGNITION CIRCUIT
432
454
456

FIG. 4

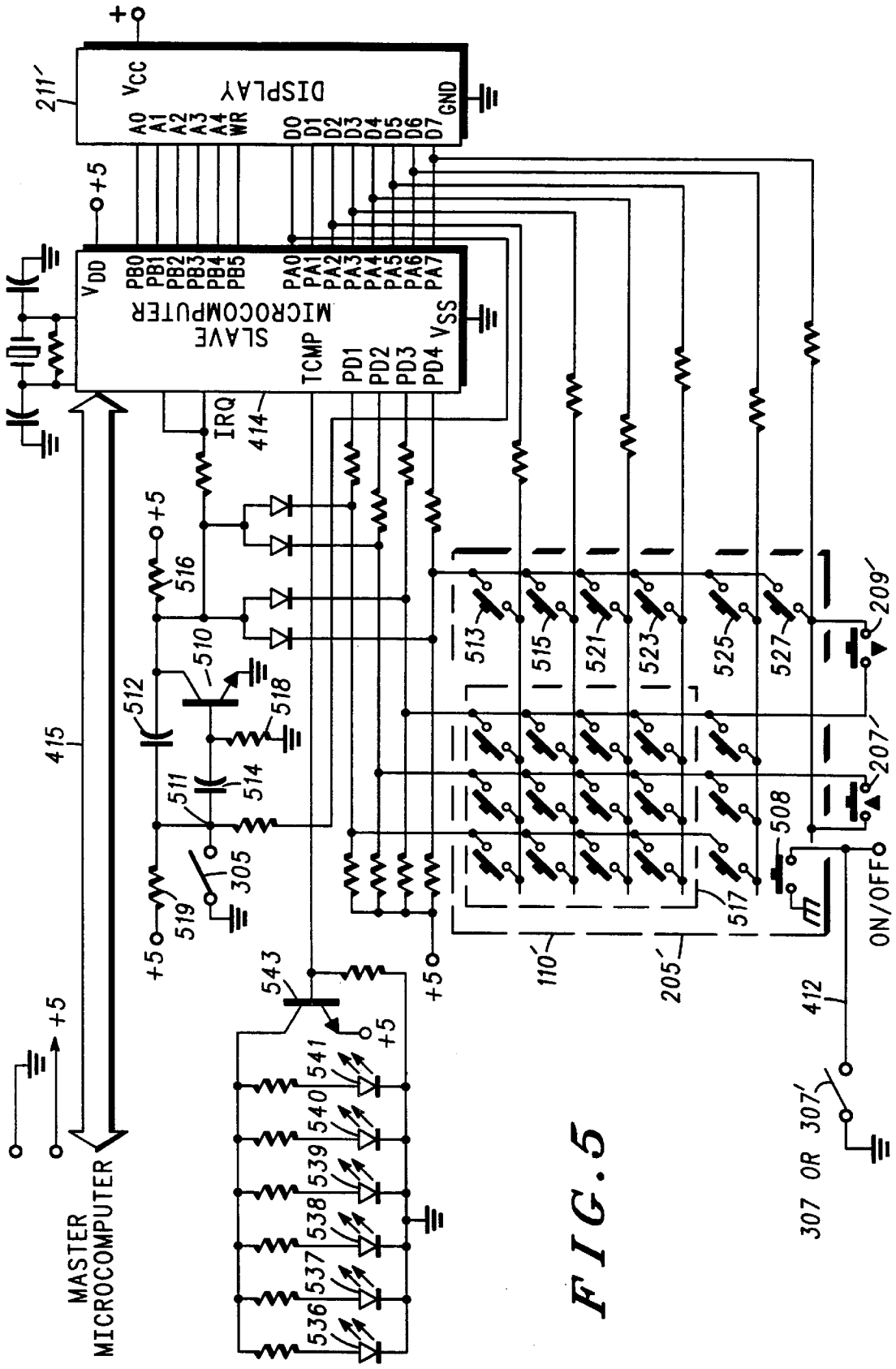

DISPLAY
MICROCOMPUTER SLAVE
MASTER MICROCOMPUTER
ON/OFF
307 OR 307'
+5
GND
IRQ
TCMP
211'
414
415
516
510
512
518
514
511
519
305
543
541
540
539
538
537
536
513
515
521
523
525
527
209'
207'
508
517
110'
205'
412

FIG. 5

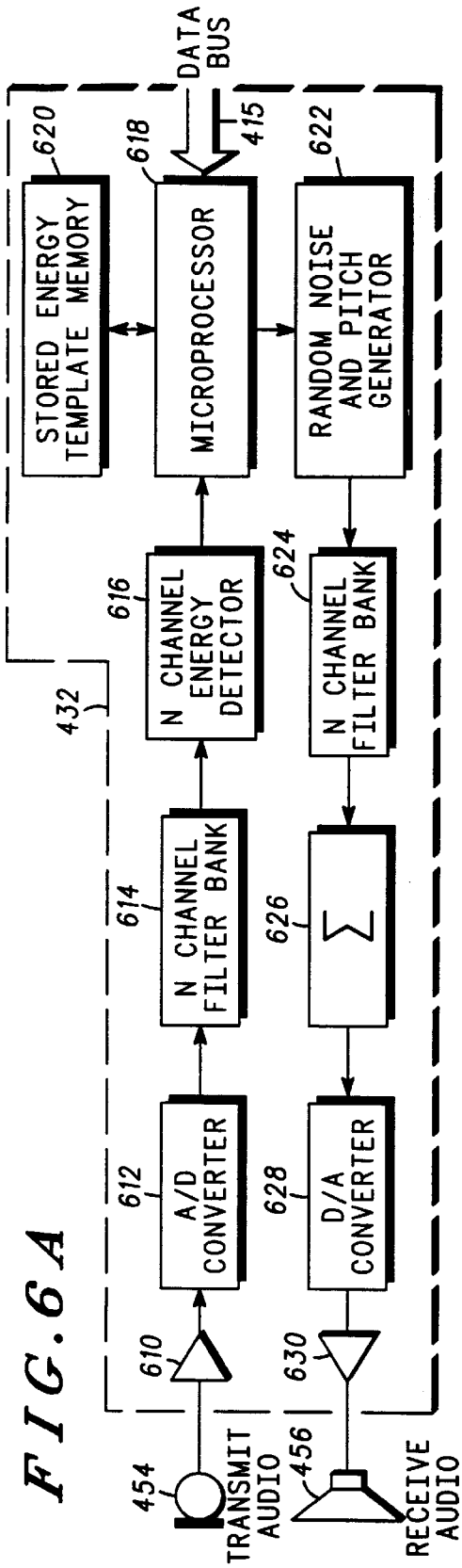

DATA BUS
415
620
STORED ENERGY TEMPLATE MEMORY
618
MICROPROCESSOR
622
RANDOM NOISE AND PITCH GENERATOR
616
N CHANNEL ENERGY DETECTOR
624
N CHANNEL FILTER BANK
432
614
N CHANNEL FILTER BANK
626
612
A/D CONVERTER
628
D/A CONVERTER
610
630
454
TRANSMIT AUDIO
456
RECEIVE AUDIO

FIG. 6A

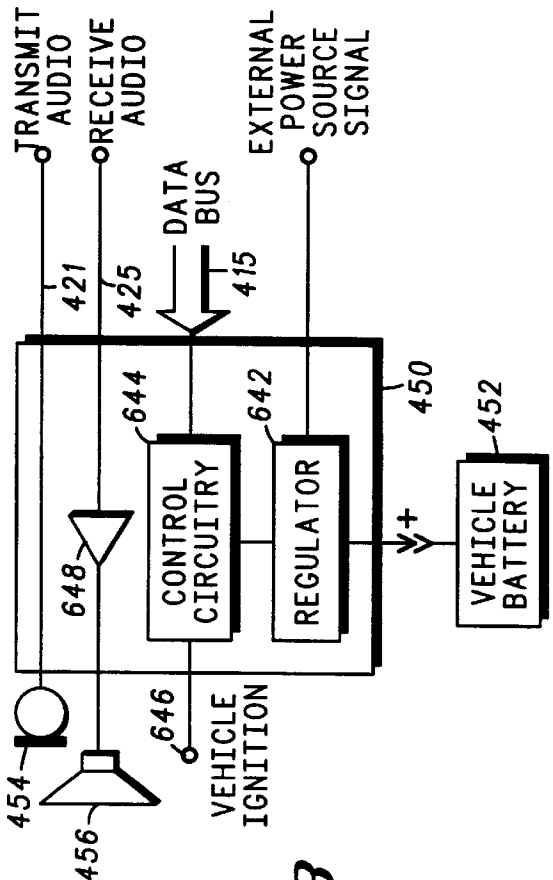

TRANSMIT AUDIO
RECEIVE AUDIO
DATA BUS
415
EXTERNAL POWER SOURCE SIGNAL
421
425
644
642
450
452
CONTROL CIRCUITRY
REGULATOR
VEHICLE BATTERY
V+
648
454
456
646
VEHICLE IGNITION

FIG. 6B

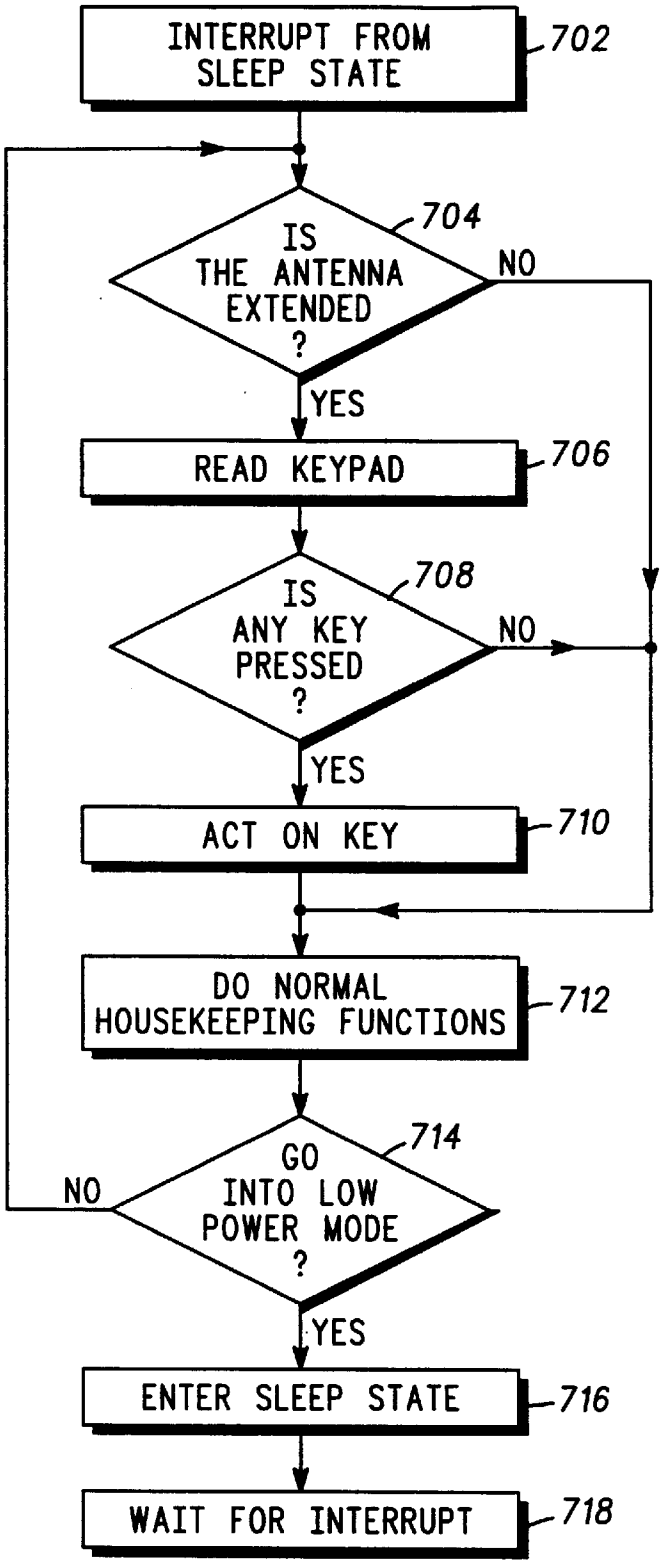

INTERRUPT FROM SLEEP STATE
702
IS THE ANTENNA EXTENDED ?
704
NO
YES
READ KEYPAD
706
IS ANY KEY PRESSED ?
708
NO
YES
ACT ON KEY
710
DO NORMAL HOUSEKEEPING FUNCTIONS
712
GO INTO LOW POWER MODE ?
714
NO
YES
ENTER SLEEP STATE
716
WAIT FOR INTERRUPT
718

FIG. 7

FIG. 8

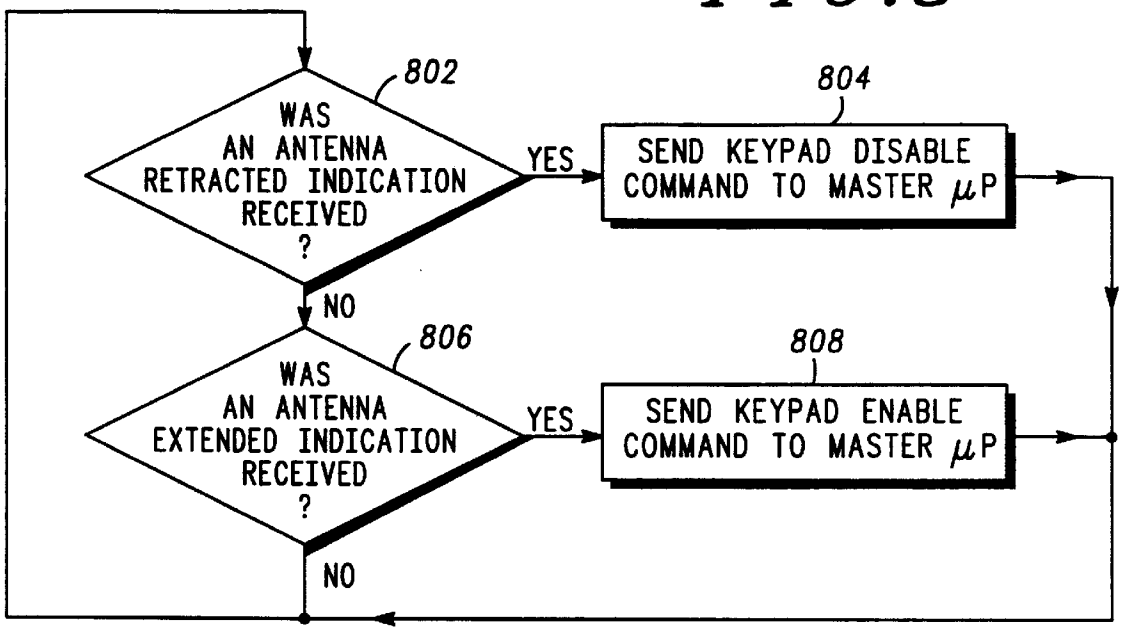
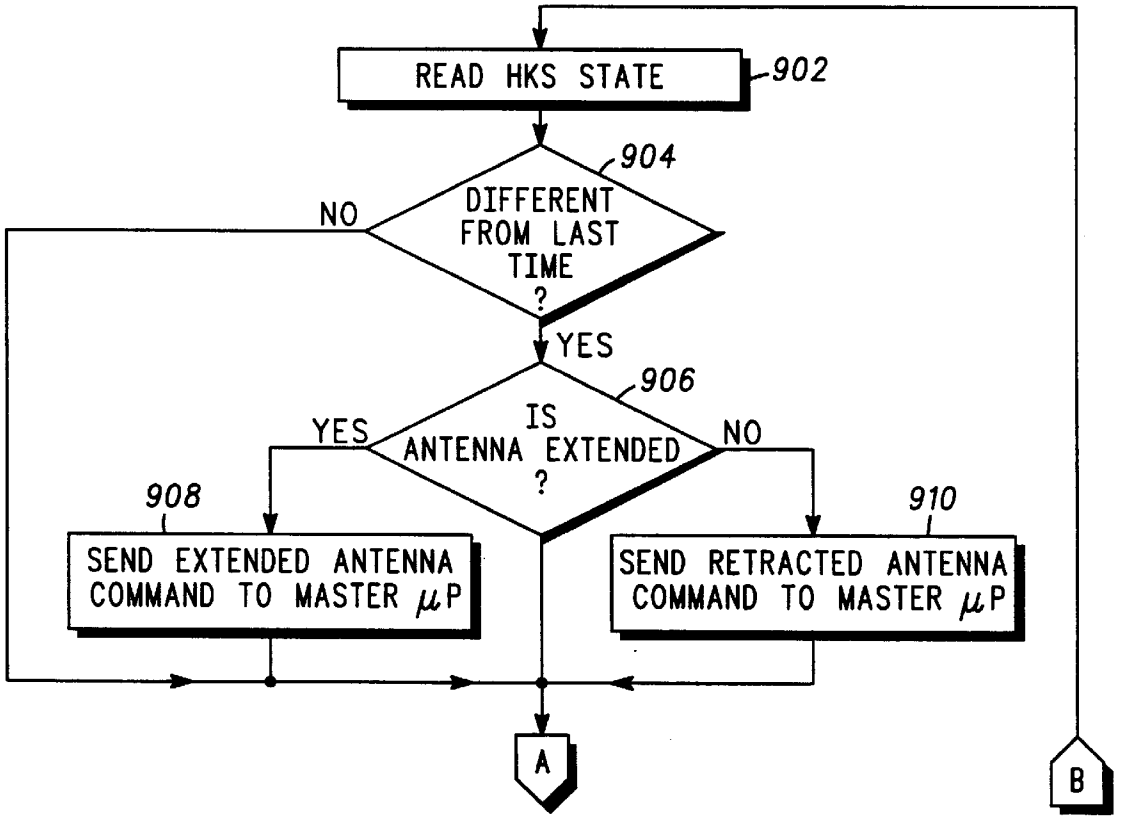

802
WAS AN ANTENNA RETRACTED INDICATION RECEIVED ?
YES
804
SEND KEYPAD DISABLE COMMAND TO MASTER μP
NO
806
WAS AN ANTENNA EXTENDED INDICATION RECEIVED ?
YES
808
SEND KEYPAD ENABLE COMMAND TO MASTER μP
NO

FIG. 9A


READ HKS STATE
902
904
DIFFERENT FROM LAST TIME ?
NO
YES
906
IS ANTENNA EXTENDED ?
YES
NO
908
SEND EXTENDED ANTENNA COMMAND TO MASTER μP
910
SEND RETRACTED ANTENNA COMMAND TO MASTER μP
A
B

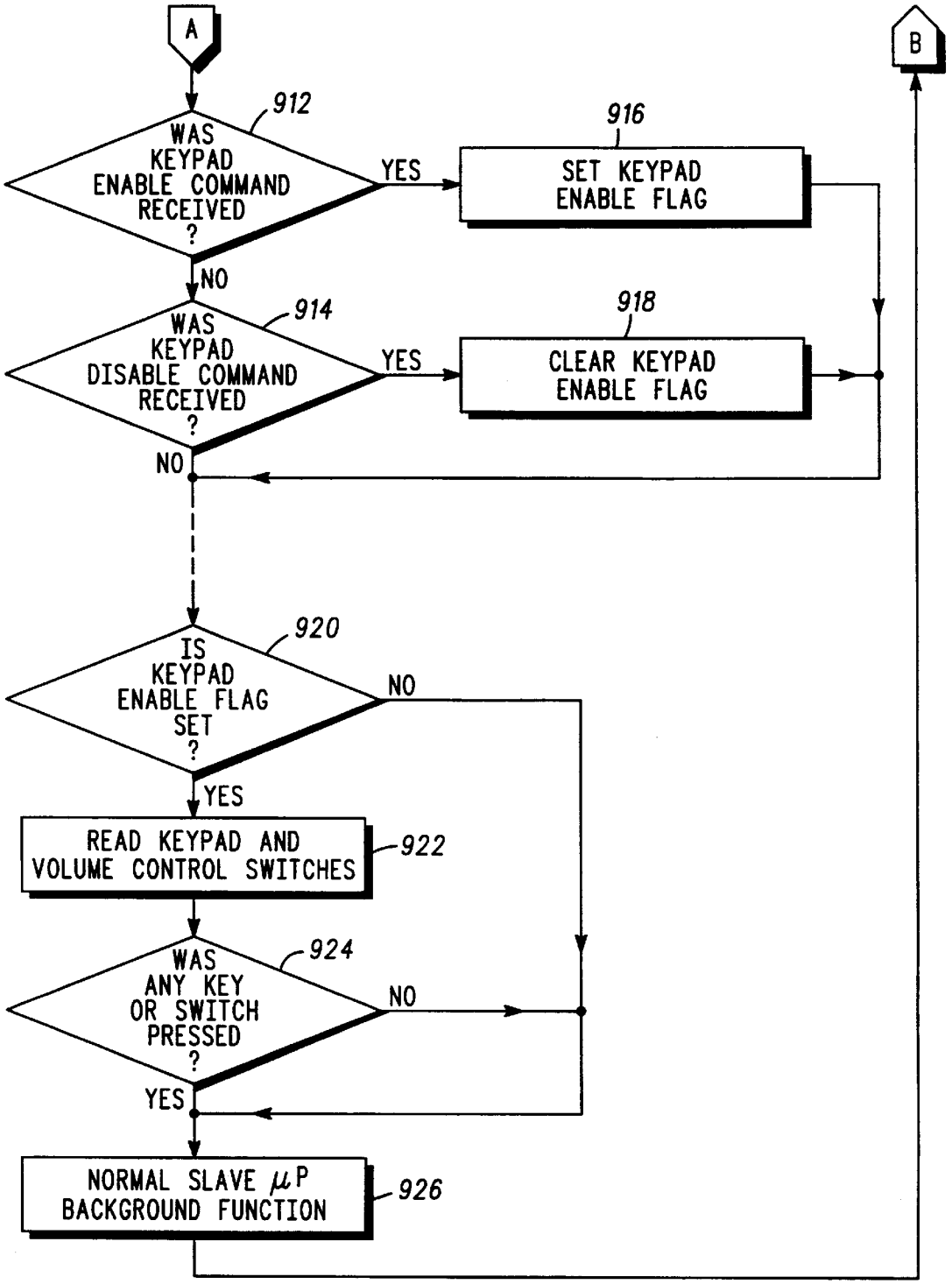

A
B
912
WAS KEYPAD ENABLE COMMAND RECEIVED ?
YES
916
SET KEYPAD ENABLE FLAG
NO
914
WAS KEYPAD DISABLE COMMAND RECEIVED ?
YES
918
CLEAR KEYPAD ENABLE FLAG
NO
920
IS KEYPAD ENABLE FLAG SET ?
NO
YES
READ KEYPAD AND VOLUME CONTROL SWITCHES
922
924
WAS ANY KEY OR SWITCH PRESSED ?
NO
YES
NORMAL SLAVE μP BACKGROUND FUNCTION
926

FIG. 9B

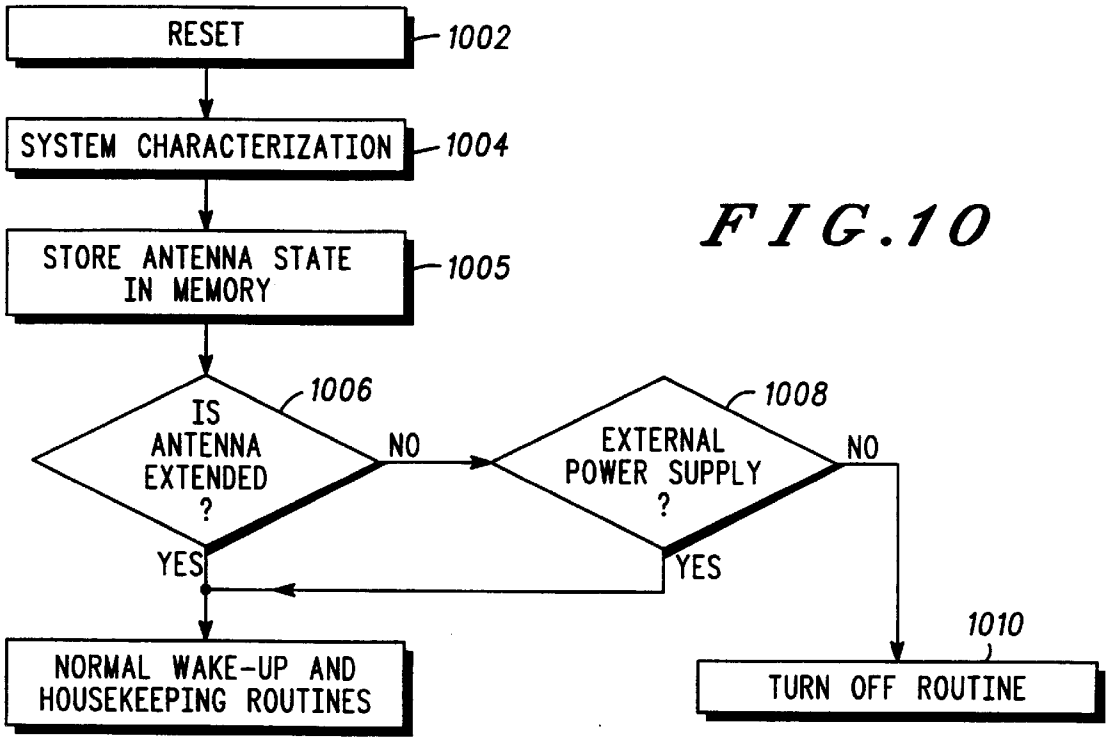

RESET
1002
SYSTEM CHARACTERIZATION
1004
STORE ANTENNA STATE IN MEMORY
1005
IS ANTENNA EXTENDED ?
1006
NO
EXTERNAL POWER SUPPLY ?
1008
NO
YES
YES
NORMAL WAKE-UP AND HOUSEKEEPING ROUTINES
1010
TURN OFF ROUTINE

FIG.10

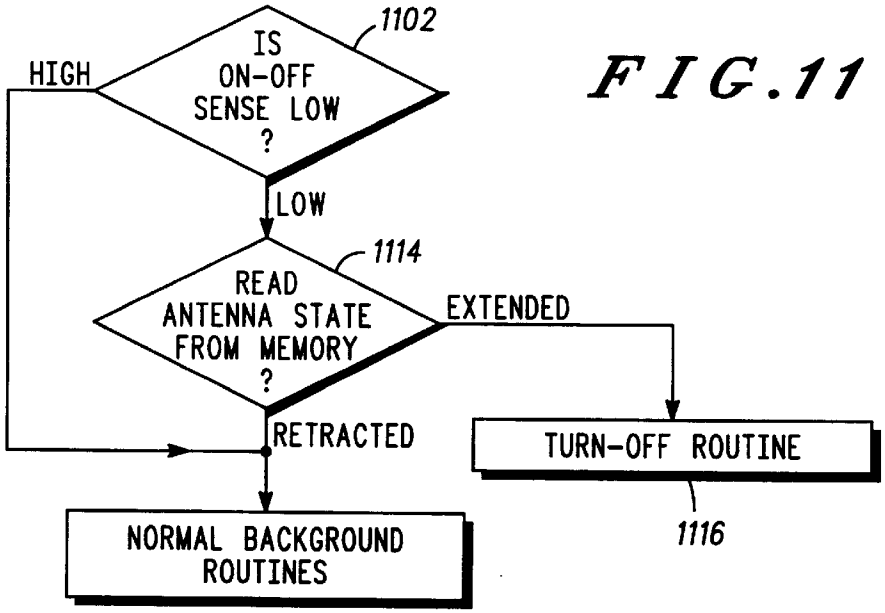

IS ON-OFF SENSE LOW ?
1102
HIGH
LOW
READ ANTENNA STATE FROM MEMORY ?
1114
EXTENDED
RETRACTED
TURN-OFF ROUTINE
1116
NORMAL BACKGROUND ROUTINES

FIG.11

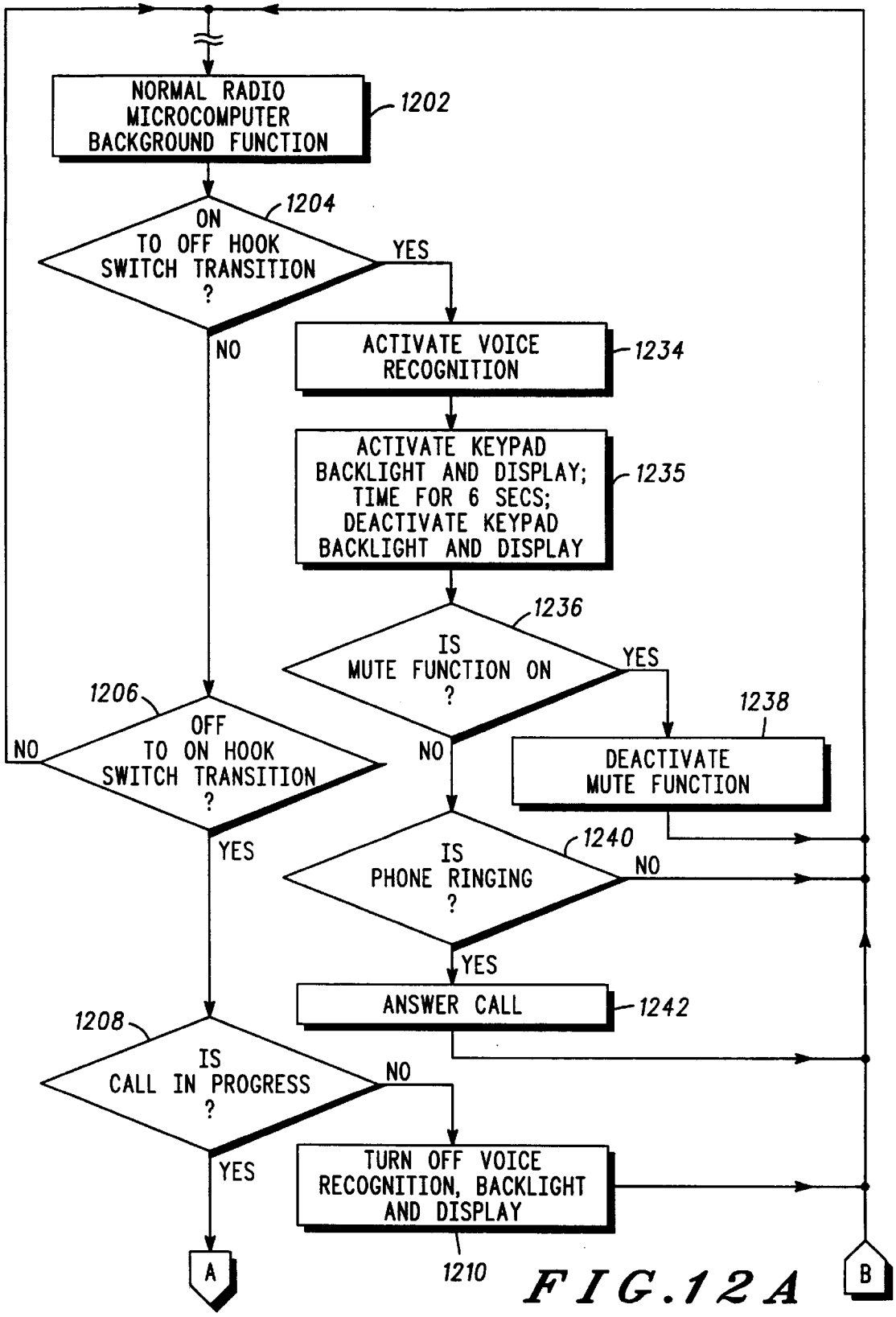
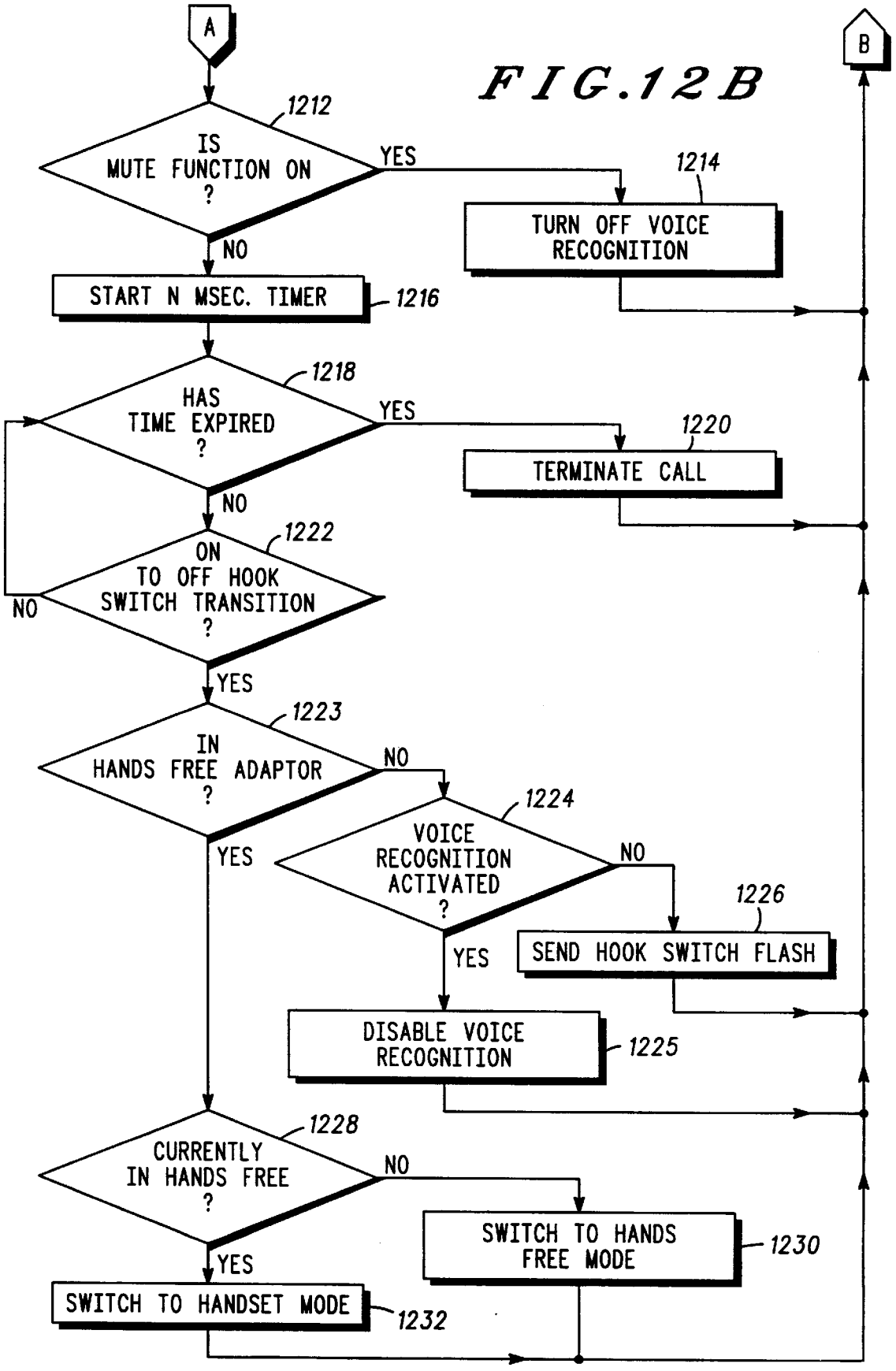

NORMAL RADIO MICROCOMPUTER BACKGROUND FUNCTION
1202
ON TO OFF HOOK SWITCH TRANSITION ?
1204
YES
NO
ACTIVATE VOICE RECOGNITION
1234
ACTIVATE KEYPAD BACKLIGHT AND DISPLAY; TIME FOR 6 SECS; DEACTIVATE KEYPAD BACKLIGHT AND DISPLAY
1235
IS MUTE FUNCTION ON ?
1236
YES
NO
DEACTIVATE MUTE FUNCTION
1238
OFF TO ON HOOK SWITCH TRANSITION ?
1206
NO
YES
IS PHONE RINGING ?
1240
NO
YES
ANSWER CALL
1242
IS CALL IN PROGRESS ?
1208
NO
YES
TURN OFF VOICE RECOGNITION, BACKLIGHT AND DISPLAY
1210
A
B

FIG. 12A

FIG. 12B


A
B
1212
IS MUTE FUNCTION ON ?
YES
1214
TURN OFF VOICE RECOGNITION
NO
START N MSEC. TIMER
1216
1218
HAS TIME EXPIRED ?
YES
1220
TERMINATE CALL
NO
1222
ON TO OFF HOOK SWITCH TRANSITION ?
NO
YES
1223
IN HANDS FREE ADAPTOR ?
NO
YES
1224
VOICE RECOGNITION ACTIVATED ?
NO
YES
1226
SEND HOOK SWITCH FLASH
DISABLE VOICE RECOGNITION
1225
1228
CURRENTLY IN HANDS FREE ?
NO
YES
SWITCH TO HANDS FREE MODE
1230
SWITCH TO HANDSET MODE
1232

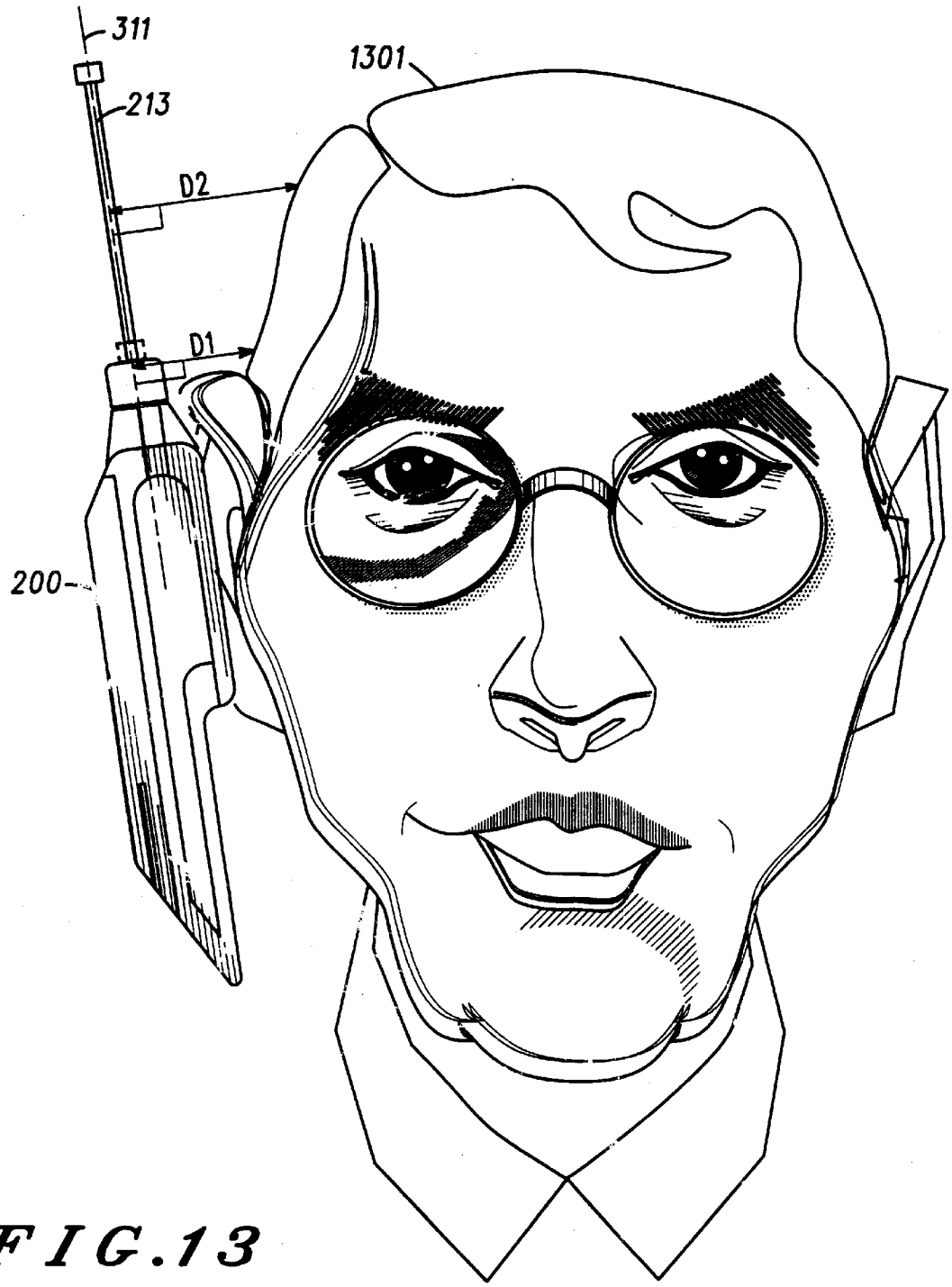


FIG.13

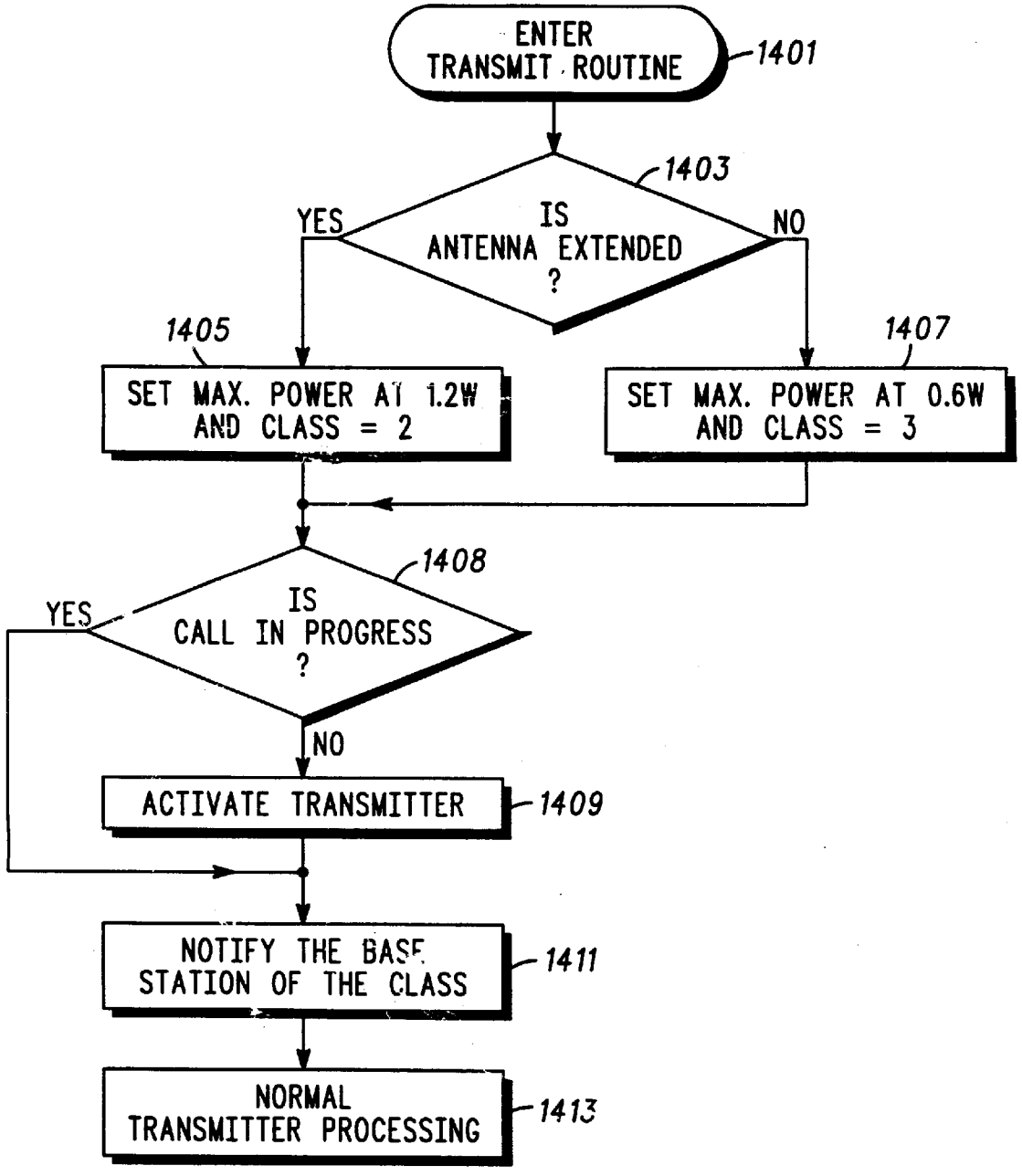

ENTER TRANSMIT ROUTINE
1401
1403
IS ANTENNA EXTENDED ?
YES
NO
1405
SET MAX. POWER AT 1.2W AND CLASS = 2
1407
SET MAX. POWER AT 0.6W AND CLASS = 3
1408
IS CALL IN PROGRESS ?
YES
NO
ACTIVATE TRANSMITTER
1409
NOTIFY THE BASE STATION OF THE CLASS
1411
NORMAL TRANSMITTER PROCESSING
1413

FIG.14

TRANSMITTER HAVING ADJUSTABLE POWER LEVELS RESPONSIVE TO THE POSITION OF A MOVABLE ANTENNA

RELATED APPLICATIONS

The present application is a Continuation in Part of patent application Ser. No. 07/729,502, entitled "Apparatus and Method for Generating a Control Signal Responsive to a Movable Antenna", filed on Jul. 12, 1991 by Kevin D. Kaschke and assigned to the assignee of the present invention.

FIELD OF THE INVENTION

The present invention relates generally to portable communication devices, and more particularly to a portable transmitting device having adjustable transmit power levels responsive to the position of a movable antenna.

BACKGROUND OF THE INVENTION

A portable communication device, of which a portable cellular radiotelephone subscriber unit is a convenient example, provides an appropriate setting for describing the need for the present invention. The small size of portable radiotelephones enables the user to carry and store the unit virtually anywhere.

Such portability is afforded by the use of a foldable housing and a movable antenna. FIG. **1** shows a foldable portable radiotelephone **100** having a housing portion **101** hinged to a body portion **103** and an antenna **109** extendably retractable along its longitudinal axis. For increased portability when the portable radiotelephone **100** is not in use, the hinged housing portion **101** is rotated to cover the keypad **105** and the antenna is retracted substantially inside to the body of the portable radiotelephone. A retracted antenna can transmit and/or receive radio frequency (RF) signals but the antenna's performance is less than an extended antenna because of its shortened electrical length and interference from the close proximity of the user's body. To use the portable radiotelephone, the hinged housing portion **101** is rotated to expose the keypad **105** and the antenna is extended to project away from the body of the portable radiotelephone for better performance.

This portability, however, allows the portable radiotelephone to be placed in locations where foreign objects may come in contact with a user interface mechanism (i.e. a keypad) and inadvertently enable or disable control functions of the radiotelephone. Such undesirable actuation of the control functions is likely to engage related functions which reduce the operating life of a storage battery which powers the portable radiotelephone and may inhibit normal operation.

U.S. Pat. No. 4,845,772 and U.S. patent applications Ser. Nos. 07/439,993 and 07/439,983 describe portable radiotelephones that enable or disable control functions of the radiotelephone responsive to the position of the hinged housing portion. Steps have been taken, however, to reduce the cost, weight and thickness of the portable radiotelephone by eliminating the hinged housing portion. In doing so, the advantages of controlling functions of the portable radiotelephone responsive to the hinged housing portion are lost.

Accordingly, there is a need for a portable communication device, of which a cellular portable radiotelephone is merely an example, having functions that can be controlled without the use of a hinged housing portion.

Portable radiotelephone antennas radiate RF electromagnetic energy while transmitting an RF signal. The human body, and more particularly, the human head is biologically sensitive to excessive levels of radiated energy. The level of exposure of the human body to the radiated energy is related at least in part to the power level of the transmitted signal and the distance between the antenna and the human body. Exposure increases with increasing power level or decreasing distance.

Portable radiotelephones, by design, are held against the user's head so that the user may conveniently listen via an earpiece speaker and talk via a microphone. Such a design results in the antenna being located near the user's head, thus unavoidably exposing the user's head to the radiated energy. Safety standards have been established by the U.S. government to safely limit the exposure of humans to the radiated energy. The safety standards have been more than met by limiting the power level of the transmitted signal.

However, a consequence of limiting the portable radiotelephone's transmit power is that the physical distance from which the portable radiotelephone may transmit a signal to a remote base station is limited. Thus, limiting the portable radiotelephone's transmitter power to meet the safety standards also limits the useful transmit range of the portable radiotelephone.

Accordingly, there is also a need for a transmitting device, of which a cellular portable radiotelephone is merely an example, that can transmit RF signals at a higher power level while limiting the exposure of humans to energy radiated by the transmitter's antenna.

A portable radiotelephone comprises antenna means including an antenna element, and a transmitter. The antenna element is moveable between a stowed position and an unstowed position. The transmitter transmits a signal from the antenna means at a first power level when the antenna element is moved to the stowed position and at a second power level, greater than the first power level, when the antenna element is moved to the unstowed position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric drawing of a portable radiotelephone having a hinged housing portion which may employ the present invention.

FIG. **2** is an isometric drawing of a portable radiotelephone without a hinged housing portion which may employ the present invention.

FIGS. **3A–3C** are side views of the portable radiotelephone of FIG. **2** having a cut-away view showing a first, second, and third embodiment, respectively, of the the radiotelephone of FIG. **2**.

FIG. **4** is a block diagram of the electronic elements of the portable radiotelephone of FIG. **2** embodying the present invention.

FIG. **5** is a schematic diagram of a slave microcomputer and associated circuitry employed in the portable radiotelephone of FIG. **4**.

FIGS. **6A** and **6B** are block diagrams of voice recognition circuitry and vehicular adaptor (hands-free) circuitry, respectively, employed in FIG. **4**.

FIG. **7** is a flowchart depicting the deactivation process employed in the slave microcomputer of FIG. **5**.

FIG. **8** is a flowchart depicting the process of activation/deactivation employed in the master microcomputer of FIG. **4**.

FIGS. **9A** and **9B**, combined, are flowcharts depicting the process of activation/deactivation employed in the slave microcomputer of FIG. **5**.

FIG. **10** is a flowchart depicting the process of activation/deactivation of the power on/off switch upon initial power-up of the master microcomputer of FIG. **4**.

FIG. **11** is a flowchart depicting the process of activation/deactivation of the power on/off switch after initial power-up of the master microcomputer of FIG. **4**.

FIGS. **12**A and **12**B are a flowchart depicting the process of interpreting hookswitch operation of the master microcomputer of FIG. **4**.

FIG. **13** is a drawing showing the change in distance between an antenna of a portable radiotelephone and a user's head when the antenna is retracted and extended.

FIG. **14** is a flowchart depicting a change the transmit power of a portable radiotelephone responsive to the radiotelephone's antenna position.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A portable radiotelephone **200** adapted for use in a cellular radiotelephone system is shown in FIG. **2**. The user may listen via the earpiece **201** and may speak into the microphone **203**. The keypad **205** consists of a plurality of buttons numbered one through zero, # and * in a familiar telephone arrangement as well as additional function buttons such as "send", "end", "clear", "function", "on/off" and other buttons associated with memory recall. Disposed on a side of the portable radiotelephone are two volume control buttons: volume increase **207** and volume decrease **209**, which may adjust the volume of the earpiece and/or the ringer. A display **211**, disposed above the keypad **205**, provides visual feedback for the buttons depressed and other operational features. A wireless communication element, for example antenna **213**, provides wireless transceiving communications between the the portable radiotelephone **200** and the cellular radiotelephone system. To reduce the cost, weight and thickness of the portable radiotelephone **200**, the hinged housing portion **101** used by the portable radiotelephone **100** of FIG. **1** is not attached to the radiotelephone **200** of FIG. **2**.

As in typical wireless communication devices, the antenna **213** is extended when the portable radiotelephone **200** is in use and retracted when the portable radiotelephone **200** is not in use. However, in addition to positioning the radiotelephone's antenna **213** for transceiving communication signals, a novel feature of the radiotelephone **200** comprises controlling a predetermined operating mode of the radiotelephone **200** responsive to the antenna's position while providing for the advantage of reduced cost, weight and thickness. The predetermined operating mode is a particular functioning arrangement or condition of the radiotelephone including but not limited to the radiotelephone's **200** power on or off state, voice recognition's on or off state, functions implemented responsive to a key depression, or transmit power.

FIGS. **3**A–**3**C illustrate a side view of a first **325**, second **326** and third **327** embodiment, respectively, of the portable radiotelephone **200** of FIG. **2**. A cut-away portion exposing a cross sectional view in FIGS. **3**A–**3**C illustrate unique switching mechanisms for implementing alternatives of the present invention. In the preferred embodiments **325**–**327** the antenna **213** may be perceived to extend (solid line) substantially outside the radiotelephone **200** or retract (dotted line) substantially inside the radiotelephone **200** along a center axis **311** of the antenna **213**. A first, second, third and fourth position of the antenna **213** inside the radiotelephone **200** are referenced to datum lines at **313**–**316**, respectively. The first position at **313** represents the position of a retracted antenna. The second position at **314** represents the position of an extended antenna. The third position at **315** represents the position of a retracted antenna further retracted into the radiotelephone **200** than the first position at **313**. The fourth position at **316** represents the position of the antenna between the first and the second position, for example, approximately half way between the retracted position at **313** and the extended position at **314** of the antenna **213**.

An example of a movable antenna that may be used in accordance with the present invention is described in U.S. Pat. No. 4,121,218. The movable antenna comprises a stationary helical coil capacitively coupled to an extendable half-wavelength radiator. The radio transmits primarily from the stationary helical coil when the half-wavelength radiator is retracted and primarily from the half-wavelength radiator when the half-wavelength radiator is extended.

The preferred embodiments **325**–**327** utilize conventional reed switches **305** and **307** electrically coupled to a printed circuit board **303** and a magnet **301** affixed to an end portion of the antenna **213** inside the radiotelephone **200**. A magnetic field given off by the magnet **301** causes the reed switches **305** or **307** to close, i.e., short circuit, when placed in close proximity to one of the reed switches and to open circuit when displaced from one of the reed switches. The reed switches **305** and **307** are coupled to the radiotelephone circuitry which takes appropriate action responsive to the open or closed state of the reed switches **305** or **307**.

Referring now to FIG. **3**A one may appreciate the advantages of the first preferred embodiment of the present invention wherein a hookswitch control signal (at line **511** in FIG. **5**) is generated responsive to the antenna's position. Once a typical portable radiotelephone is turned "on" by conventionally depressing the "on/off" key on the keypad **205**, answering, terminating or readying a telephone call requires a key depression or rotating the aforementioned hinged housing portion to generate the hookswitch control signal. Additionally, the antenna is typically extended during use for optimal wireless communication performance and retracted when not in use.

In the first preferred embodiment, however, the hookswitch control signal at line **511** of FIG. **5** is generated responsive to the position of the antenna **213** relative to the portable radiotelephone **325**. Thus the key depression or rotation of the hinged housing portion to generate the hookswitch control signal at line **511** of FIG. **5** is eliminated. This feature of the radiotelephone **325** provides the user greater convenience in operating the radiotelephone. The user may answer a telephone call by simply extending the antenna **213**.

Extending the antenna **213** may also ready the portable radiotelephone to make a call. Such a state of answering or readiness to make a call is commonly know as "off-hook". To make a call, the user enters the appropriate phone number through the keypad and depresses the "send" button to activate the portable radiotelephone's transmitter thereby initiating communication with the cellular radiotelephone system. In the first preferred embodiment, the "send" key **513** (FIG. **5**) may also be used to answer a telephone call if the antenna is already extended. The user may terminate the telephone call by retracting the antenna **213**. Such a retracted state of the antenna is commonly known as "on-hook". In the first preferred embodiment, the "end" key **515** (FIG. **5**) may also be used to terminate a telephone call if the antenna is already extended.

In FIG. **3A**, one may perceive the generation of the hookswitch control signal at line **511** of FIG. **5** responsive the antenna **213** being moved between the retracted position at **313** and the extended position at **314**. An "on-hook" control signal is generated when the antenna **213** is retracted substantially inside the portable radiotelephone **325** to the first position at **313** such that the magnet **301** on the end portion of the antenna **213** is in close proximity with the reed switch **305**. The magnetic field given off by the magnet **301** causes the reed switch **305** to short circuit thereby placing the radiotelephone **325** in the "on-hook" state. Extending the antenna **213** substantially outside the portable radiotelephone **325** to the second position at **314** displaces the magnetic field given off by the magnet **301** from the reed switch **305** causing the reed switch **305** to open circuit placing thereby placing radiotelephone **325** in the "off-hook" state. In the first preferred embodiment, the combination of the magnet **301** and the reed switch **305** coupled to the printed circuit board **303** may be known as the hookswitch. In the first preferred embodiment, the antenna **213** has at least two positions relative to the radiotelephone **325** in order to generate both the "on-hook" and "off-hook" operating modes.

To generate the "on-hook" and "off-hook" operating modes without positioning the antenna **213**, the user may also conventionally depress the "end" **515** and "send" **513** keys, respectively, on the keypad **205**. Similar radiotelephone devices, such as conventional cordless radiotelephones, have a dedicated switch to produce the "on-hook" and "off-hook" operating modes. In the first preferred embodiment, the "on-hook" and "off-hook" operating modes are produced by actuating the "send" **513** or "end" **515** keys on the keypad **205** or by moving the antenna **213** to provide optimum user convenience and functionality for the radiotelephone if the antenna should become inoperable.

Table **1** describes the "on-hook" and "off-hook" operating modes produced by actuating the "send" **513** or "end" **515** keys or by moving the antenna **213** after the radiotelephone **325** is already turned "on". The "end" and "send" key depression may place the radiotelephone in an "on-hook" or "off-hook" state, respectively. The antenna position may be extended (out) outside the radiotelephone, or retracted (in) within the radiotelephone. Extending the antenna **213** places the radiotelephone **325** "off-hook" regardless of whether the radiotelephone **325** was placed in the "on-hook" or "off-hook" by a key depression. Similarly, retracting the antenna **213** places the radiotelephone **325** in the "on-hook" state regardless of whether the radiotelephone **325** was placed in the "on-hook" state or in the "off-hook" state by a key depression.

TABLE 1

Hookswitch state after the key depression.	Antenna movement.	Hookswitch state after the antenna movement.
on-hook	in to out	off-hook
off-hook	in to out	off-hook
on-hook	out to in	on-hook
off-hook	out to in	on-hook

Determining the hookswitch state responsive to the position of the antenna not only simplifies operation of the portable radiotelephone for the user but also allows certain control functions to be advantageously enabled or disabled at the appropriate time. Control functions related to the mode of operation of the portable radiotelephone **325** may be disabled to prevent accidental operation when the antenna **213** is in its retracted position at **313**, i.e., when the portable radiotelephone **325** is not in use, and may be enabled when the antenna **213** is in its extended position at **314**, i.e., when the portable radiotelephone **325** is in use.

For example, when the portable radiotelephone **325** is in its standby condition, i.e., turned "on" but in a low power mode to conserve battery power while awaiting a telephone call, it would be undesirable to have the previously described foreign object inadvertently turn the radiotelephone **325** off or initiate a battery power draining function such as a key depression. Therefore, retracting the antenna **213** on the portable radiotelephone **200** may disable user interface controls, either on the keypad **205** or on other peripheral surfaces of the radiotelephone **325**, such as the "on/off" **508**, number dialling **517**, volume controls **207'** and **209'**, "send" **513**, "end" **515**, "clear" **521**, "function" **523** and memory store **525** and recall **527** controls. Additionally, a retracted antenna at **313** may disable circuitry such as voice recognition circuitry as shown in FIG. **6A** and hands-free circuitry as shown in FIG. **6B**. Extending the antenna **213** enables the aforementioned disabled control functions and circuitry as well as keypad illumination **536–541** and display circuitry **211'** per FIG. **5**.

Referring now to FIG. **3B**, an illustration of the second preferred embodiment, one may perceive the generation of the on/off power control signal responsive to the antenna position. In the second preferred embodiment, the user need only extend the antenna **213** and the portable radiotelephone **326** automatically turns "on" thus eliminating both of the previously described typical steps of opening the hinged housing portion and depressing the "on/off" key **508** (FIG. **5**). Likewise, to turn "off" the portable radiotelephone **326**, the user need only retract the antenna **213** again eliminating both of the previously described typical steps of depressing the "on/off" key **508** and closing the hinged housing portion. In the second preferred embodiment, the "on-hook" and "off-hook" operating modes are generated using a conventional key depression. A further advantage of the second preferred embodiment allows the designer of the portable radiotelephone to eliminate the "on/off" key on the keypad **205** completely thus reducing the cost and surface area of the keypad.

Generating the on/off power control signal responsive to the antenna position may be conveniently used with a second-generation cordless telephone service called CT-2. One feature of the CT-2 cordless telephone is that it will only allow outgoing calls. Therefore, the user should not have a need to extend the antenna without the intention of making a telephone call, i.e., the cordless telephone must be powered "on".

An on/off power control signal **412** (FIG. **4** and **5**) is generated when the antenna **213** is moved from its retracted position at **313**, past the half way position at **316** to its extended position at **314**. Generation of the on/off power control signal **412** in the second preferred embodiment occurs when magnet **301** momentarily short circuits the reed switch **307** at the half way position at **316**. As the antenna **213** passes the half way position at **316**, the magnetic field given off by the magnet **301** comes in close proximity with the reed switch **307** causing the reed switch **307** to momentarily short circuit thereby generating the on/off power control signal **412**.

The movement of the antenna from the retracted position at **313** through the half way position at **316** to the extended

position at **314** causes the reed switch **307** to be momentarily actuated producing the on/off power control signal **412** to turn the radiotelephone "on". The movement of the antenna from the extended position at **314** past the half way position at **316** to the retracted position at **313** causes the reed switch **307** to be momentarily short circuited producing the on/off power control signal **412** to turn the radiotelephone "off".

A logic interface circuit in a power controller **410** (FIG. **4**) detects the momentary reed switch closure and initiates the steps to turn the portable radiotelephone **326** "on" if previously "off" or "off" if previously "on". Details describing the logic interface circuit may be referenced in U.S. Pat. No. 4,798,975 entitled "High Noise Immunity Input Level Detector With Hysteresis", filed in behalf of Walczak et. al. and assigned to the assignee of the present invention. Other logic interface circuits may also be used to detect the momentary reed switch closure.

To conventionally turn "on" or "off" the portable radiotelephone **326** without positioning the antenna **213**, the user may also depress the "on/off" key **508** on the keypad **205**. In a first alternative to the second preferred embodiment of the present invention, the depression of the "on/off" key **508** or moving the antenna **213** may generate the on/off control signal **412** to provide optimum user convenience and functionality for the radiotelephone if the antenna should become inoperable.

In a second alternative of the second preferred embodiment the radiotelephone **326** utilizes a continuously open or closed switch to determine the on/off power operating mode. For example, cordless radiotelephones do not use a momentary on/off power switch. Conventional cordless radiotelephones have a slide switch which places the radiotelephone in the "on" mode when short circuited and places the radiotelephone in the "off" mode when open circuited. The "on" or "off" mode of a cordless radiotelephone may utilize the present invention by positioning the reed switch **307** at one extreme of the antenna movement. In FIG. **3**B the alternative position for the reed switch **307'** is shown at position **314**. Thus, when the antenna **213** is retracted to **313**, the reed switch **307'** is open and the radiotelephone **326** is in the "off" operating mode. Likewise, when the antenna is extended to **314**, the reed switch **307'** is closed and the radiotelephone **326** is in the "on" operating mode.

Referring now to FIG. **3**C, an illustration of the third preferred embodiment, one may perceive the generation of both the hookswitch **511** and the on/off power control **412** signals responsive to the antenna position. Depressing the "on/off" key **508** on the keypad **205** to generate a power control signal **412** and the "send" **513** or "end" **515** key on the keypad **205'** to produce the hookswitch operating mode are combined with the antenna movement to provide optimum user convenience and radiotelephone functionality should the antenna become inoperable. In the third preferred embodiment, the antenna **213** has at least three positions. The hookswitch control signal **511** is generated responsive to positioning the antenna between the first retracted position at **313** and the second extended position at **314** as previously described in the first preferred embodiment. The on/off power control signal **412** is generated responsive to momentarily positioning the antenna **213** in the third position at **315** also on the axis of the antenna **311**.

To power "on" the portable radiotelephone using the antenna **213**, the user would momentarily position the antenna in the third position **315** by depressing the exposed portion of the retracted antenna **213** into the radiotelephone. Upon depressing the antenna **213**, the end portion of the antenna inside the radiotelephone presses against a spring **319** of nonmagnetic material generating a spring force against the end of the antenna **213** along the antenna axis **311**. One end of the spring **319** is attached to a support **321** to fixture the spring **319**. The other end of the spring **319**, opposite the support **321**, extends into free space and may be forced upon by the antenna **213**.

The force applied by the user overcomes the opposite force returned by the spring **319** so that the magnet **301** moves from its position at **313** in proximity to the reed switch **305** to the position at **315** in proximity to the reed switch **307**. The spring **319** completely collapses when the magnet **301** is closest to the reed switch **307** so that the magnet does not move past the reed switch **307**. Consequently, the reed switch **305** becomes an open circuit and the reed switch **307** becomes a closed circuit.

When the user releases the applied force on the exposed end portion of the antenna, the spring **319** forces the antenna **213** to its normally retracted position at **313** which causes reed switch **307** to become an open circuit and the reed switch **305** to become a short circuit. The antenna may then be positioned to the extended position at **314** or the retracted position at **313** to generate the "off-hook" or "on-hook" states, respectively. The force required by the user to position the antenna in the third position at **315** by compressing the spring **319** is substantially greater than the force required to move the antenna between the retracted **313** and extended **314** positions. Thus, the radiotelephone may not be unintentionally turned "on" or "off" when positioning the antenna to generate the hookswitch signal **511** and may be inhibited from accidental actuation of the on/off control signal **412** produced by positioning the antenna at position **315**.

The third preferred embodiment includes the advantages of both the aforementioned first and the second preferred embodiments. The on/off and hookswitch control signals generated by the antenna may also be generated by a key depression giving the user optimal convenience and radiotelephone functionality if the antenna **213** should become inoperable.

An alternative to generating the on/off control signal described in the third preferred embodiment comprises spinning the antenna **213** about the axis **311** of the antenna **213** as shown at **323** instead of depressing the antenna to the third position at **315**. Conventional switching mechanisms responsive to a spinning motion about an axis are well know to those skilled in the art and may be employed in this alternative. Axial displacement of the antenna between the retracted and extended positions at **313** and **314** respectively, would continue to generate the hookswitch control signal at **511**. The advantage of the spinning movement of the antenna **213** is that, in some user applications, spinning the antenna **213** about its axis **311** would make the antenna **213** substantially more immune to accidental power actuation than depressing the antenna into the radiotelephone **326** along its axis **311** to position **315**.

A variety of antenna structures are well known in the art and may be used to implement the present invention so long as the antenna **213** is movable. Although the preferred embodiment describes an antenna **213** which extends and retracts axially with respect to the portable radiotelephone **200** this should not be a limitation of the present invention for other antenna movements may be used to generate the control signal if so desired. For example, one such antenna movement may comprise rotating the antenna about its point of attachment to the portable radiotelephone such that the

antenna folds along side the radiotelephone when not in use and is rotated away from the radiotelephone when in use. Another such antenna movement may comprise spinning the antenna **213** about its axis when the antenna is either extended or retracted.

A variety of switching mechanisms are also well known to one skilled in the art and should not be limited to the magnet/reed switch combination as described in the preferred embodiments **325–327**. Other such switching mechanisms may comprise microswitches and printed circuit board switches. Mechanisms for positively positioning the antenna **213** in at least one of the two positions are well known to one skilled in the art and may be advantageously implemented in conjunction with the present invention. Although the radiotelephones **200** is capable of transmitting and receiving radio frequency signals, the present invention may also be used with wireless communications devices which only transmit or receive radio frequency signals. Such devices which only receive signals may include conventional AM/FM radios or any receiver utilizing an antenna. Devices which only transmit signals may include remote data input devices.

Referring to FIG. **4**, there is essentially illustrated an electrical block diagram of the cellular portable radiotelephone **200** of FIG. **2** embodying the present invention. Such a portable radiotelephone **200** includes a cellular radiotelephone transceiver **402** operable in cellular radiotelephone systems, internal microphone **420** and switchable amplifier **422**, internal speaker **424** and switchable amplifier **426**, master microcomputer **404** with conventional RAM (storing pertinent cellular telephone call parameters) and conventional ROM (storing control software), a power controller **410** including regulators coupled to a battery **430** for generating DC (Direct Current) voltages for powering other blocks and coupled to a on/off terminal **412**, a slave microcomputer **414** including conventional ROM with controlling software for controlling the display **211'** and the keypad **205'**, a voice recognition circuit **432**, a vehicular adapter (hands-free) circuit **450** and watch dog functions **406**. External microphone **454**, external speaker **456** and a vehicle battery **452** interface with the portable radiotelephone in a vehicular installation.

Master microcomputer **404**, slave microcomputer **414**, voice recognition circuit **432**, vehicular adapter (hands-free) circuit **450** and watch dog functions **406** are coupled to and communicate with one another by way of a three-wire data bus **415**, which operates as described in U.S. Pat. Nos. 4,369,516 and 4,616,314 (incorporated herein by reference).

The foregoing transceiver and microcomputer blocks may be conventional blocks of commercially available portable radiotelephones, such as, for example, the "MICROTAC PT" Cellular Telephone available from Motorola, Inc. The "MICROTAC PT" Cellular Telephone is described in further detail in operator's manual no. 68P81150E49, published and available from Motorola C & E Parts, 1313 E. Algonquin Rd., Schaumburg, Ill. 60196.

Audio signals are converted into electrical signals by the internal microphone **420** and are coupled by switchable amplifier **422** to the radio transceiver **402** via conductor at line **421**. These signals are then used to modulate the transmitter of the transceiver **402** in conventional fashion. Likewise, signals received by the receiver of transceiver **402** are coupled via conductor at line **425** to switchable amplifier **426** and subsequently to speaker **424** for conversion to acoustic signals.

When the portable radiotelephone is in the voice recognition mode, the signals from the microphone **420** are coupled by switchable amplifier **422** to voice recognition circuit **432** via the conductor at line **421**. Audio signals generated by the voice recognition circuit **432** are coupled via conductor at line **425** for connection to the amplifier **426** and subsequently to the speaker **424**.

In the preferred embodiment, two interconnected microcomputer systems are utilized to control the basic functions of the portable radiotelephone (the master microcomputer **404**) and to control the keypad and display functions (the slave microcomputer). The slave microcomputer is shown in more detail in the schematic of FIG. **5**. The slave microcomputer **414** consists of a microcomputer **414** which, in the preferred embodiment is an MC68HC05C4 microcomputer (which also has onboard memory). The basic function of the slave microcomputer is to provide interface to the user of the portable radiotelephone via keypad **205'**, display **211'**, and other buttons, indicators and illumination backlighting. The slave microcomputer **414** is coupled to a multi-segment display **211'** which, in the preferred embodiment is a conventional LED 8 digit display. The slave microcomputer **414** is also coupled to a keypad matrix of key switches **205'** which enables the portable radiotelephone user to input "dial" telephone numbers **517**, store and recall telephone number information and perform other radiotelephone functions (such as initiate or terminate a telephone call).

In the preferred embodiments, one of the keys of the matrix **205**, **508**, is specially dedicated to the function of turning the power "on" and "off". The on/off control is accomplished by a momentary switch closure by key **508** to ground which activates on/off circuitry. Volume increase switch **207'** and volume decrease switch **209'** are electrically coupled to the slave microcomputer **414** as part of the row/column matrix. Their physical location is away from the keypad **205'** on a peripheral surface of the radiotelephone **200** as shown in FIG. **2** to allow for greater user convenience. Additional keys such as the "send" **513**, "end" **515**, "clear" **521**, "function" **523** and memory "store" **525** and "recall" keys an also provided for typical radiotelephone operation.

The on/off function normally performed by the on/off switch **508** on the keypad **205'** may also be performed using the switch **307** shown schematically in FIG. **5**. A direct current circuit is made or broken by the switch **307** to ground and applied to the on/off line at **412** as an input to the power controller **410**.

The function which is normally performed by a hookswitch in a conventional landline telephone is performed in the portable radiotelephone of the present invention as previously described in relation to FIG. **3**. The hookswitch is shown schematically as switch **305** in FIG. **5**. A DC (Direct Current) circuit is made or broken by the hookswitch **305** to ground and applied to the microcomputer **414** via the hookswitch control signal at line **511**. Furthermore, a pulse is generated from any change of state of the hookswitch **305** by a transistor **510**, capacitors **512** and **514** and resistors **516**, **518**, and **519**. The output of the transistor **510** is taken from the collector and applied to the interrupt request (IRQ) input and the keypad column inputs of microcomputer **414** having a negative duration of approximately **10** microseconds. Slave microprocessor **414** stores the status of the hookswitch **305** and provides an indication of the change of state of the hookswitch **305** to the master microcomputer **404**.

Communication between the slave microcomputer **414** and the master microcomputer **404** is maintained on a data bus **415**. This data bus **415** is coupled to the master microcomputer **404** as shown in FIG. **4**. Other functions also share

the data bus **415** including the voice recognition circuit **432** and the vehicular adapter circuit **415**. Assuming that the portable radiotelephone has been turned "on", a keypad **205'** depression by the portable radiotelephone user results in a communication between the slave microcomputer **414** and the master microcomputer **404** via the bus **415**. The slave microcomputer **414** in the preferred embodiment communicates that a closure has occurred between a particular row and a particular column corresponding to the key pressed by the user. The master microcomputer **404** may then take appropriate action such as returning a digit instruction via the bus **415** for the slave microcomputer **414** to cause the display **211** to illuminate or otherwise display a character. Thus, the slave microcomputer **414** is commanded by the master microcomputer **404** or the user in order to complete an assignment.

Illumination for the keypad **205'** is provided, in the preferred embodiments, by a plurality of light emitting diodes (LEDs) indicated by diodes **536** through **541** in FIG. **5**. LEDs **536** through **541** are conventionally supplied from a regulated 5 volt voltage source via current limiting resistors and switch transistor **543**. Switch transistor **543** is coupled to the TCMP port of the slave microcomputer **414** and is enabled/disabled in accordance with the stored program of the slave processor **414**. The LEDs are physically mounted behind the keypad **205** shown in FIG. **2** and provide backlighting to the keys to aid the user in selecting the keys in dim lighting conditions.

Referring now to FIG. **6**A, there is illustrated a block diagram of a voice recognition circuit **432** which may be utilized in the present invention. When the voice recognition circuits are activated, microphone audio from an external microphone **454** is coupled to amplifier **610** where the gain is increased to an appropriate input level for the A/D converter **612** and to a transmit (TX) audio path **421**. The A/D converter **612** digitizes the amplified analog input signal from the amplifier **610**. The digitized signal from the A/D converter **612** is fed into a filter bank **614** comprised of 'n' bandpass filters whose responses overlap at the 3 dB response points. The output from each of the filter bank channels is fed to an 'n' channel energy detector **616** where the amplitude of the signal in each bandpass response is detected. The detected level from each energy detector, at **616**, is fed to a conventional microcomputer **618** for comparison with a stored energy template from memory **620**. Upon successful correlation of the microphone input with the stored template, microcomputer **618** sends a command on the data bus **415** to the master microcomputer **404**. In this manner, a command such as a telephone number to be dialed or a "send" or "end" command may be entered to control radiotelephone operation.

Synthesized voice replies from the voice recognition circuits are initiated by the microcomputer **618** by sending control signals to a random noise generator and pitch generator circuit **622**. Signals from these generators are fed to an 'n' channel filter bank **624** which comprises 'n' narrow bandpass filters. The output of these filters are added together in a summer block **626** whose output is fed to a D/A converter **628** where the digital signal is converted to an analog signal. The analog signal is amplified to an appropriate level with amplifier **630** and sent to the receive (RX) audio path **425** which is then sent to the external speaker **456** so that the user will hear the synthesized voice responses. The voice recognition circuits may be activated by the master microcomputer **404** by sending commands to the voice recognition processor **618** over the data bus **415**. Similar voice recognition circuits are further disclosed in U.S. Pat. Nos. 4,797,929; 4,817,157; 4,870,686; 4,896,361; 4,945,570; U.S. patent application Ser. No. 07/266,293 ("Word Spotting In a Speech Recognition System Without Predetermined End Point Detection", filed on behalf of Gerson on Oct. 31, 1988) and international publication numbers WO 87/07748 and WO 87/07749 (Dec. 17, 1987).

Referring to **6**B there is shown a block diagram of a hands-free vehicular adapter circuit which may be employed in the present invention. The vehicular adapter **450** may be a hands-free adapter with a regulated power supply which couples the portable radiotelephone to a vehicle battery **452**. When coupled to duplex hands-free adapter (DHFA) the portable radiotelephone is in the DHFA mode, in which, inter alia, display **211** is disabled when the portable radiotelephone is inactive for a period of time.

Master microcomputer **404** detects the presence of an external power source by monitoring an external power source signal from the vehicular adapter circuit **450**. The external power source signal is converted to a binary signal have a binary state indicating whether or not the external power source is present (i.e., binary 0 state equals external power source present).

If the portable telephone is in the DHFA mode, audio amplifiers **422** and **426** are disabled and the TX audio at **421** and RX audio at **425** are routed to the hands-free circuitry of the vehicular adapter circuit **450** for processing and coupling to the hands-free microphone **454** and speaker **456**, respectively, as shown in FIG. **6**B.

The portable cellular radiotelephone receives its power via the external power source connection which is the output of conventional voltage regulator **642**. The voltage supplied by the vehicle battery **452** is voltage regulated and controlled by voltage regulator **642**. Control circuitry **644** turns the regulator output on and off in response to signals from the vehicle ignition input at port **646** and data bus **415**. Data bus **415** is used by the portable radiotelephone to sense if a hands-free adapter **450** is plugged into the portable radiotelephone. RX audio signal at **425** from the portable radiotelephone is coupled to the amplifier **648** in hands-free adapter **450** to boost the level to drive speaker **456**. The output from microphone **454** is connected to the portable radiotelephone via TX audio connection at **421**.

Although the preferred embodiments have been implemented employing two microcomputers, this should not be a limitation of the invention for it is possible to implement the present invention in a single microcomputer should the designer so desire. For a single microcomputer or a multiple microcomputer system the microcomputers may be interrupt driven in order to save battery power.

FIGS. **7** through **12**B represent the processes followed to realize the preferred embodiments **325** and **327** of the present invention which generate a hookswitch signal responsive to the antenna position. Referring now to FIG. **7**, processes followed by the slave microcomputer **414** in realizing the present invention are illustrated in flowchart form. The process of FIG. **7**, therefore, commences with an interrupt due to a change of state of the hookswitch **305** to enable the microcomputer system at **702**. A determination is made, at **704**, whether the antenna is extended or retracted. If the antenna is extended, then the keypad **110** is read to determine which key has been closed at **706**. If a key has been depressed, at **708**, then the function or character designated by the key is acted upon at **710**. If a keypad key has not been depressed, then no action is taken and the microcomputer system resumes its normal functions of controlling the transceiver, the display, and other housekeep-

ing chores as shown at **712**. If it is determined that the antenna is retracted at **704**, then any keypad key depression is considered to be spurious and is ignored by progressing directly from the determination block at **704** to the normal housekeeping functions block at **712**. The entire process is repeated for a predetermined period of time until a determination is made that the microcomputer system should go into a low power consumption mode as determined at **714**. The microcomputer system is put into a "sleep" state at **716** and only the low power functions await for an interrupt signal at **718**.

If the microcomputer system is implemented as a master and a slave microcomputer, the master microcomputer utilizes the process shown in FIG. **8** (as part of its standard operating procedure) to prevent spurious key depressions from activating the portable radiotelephone. Since the slave microcomputer **402** can send either an antenna extended indication or an antenna retracted indication, a detection of those indications is necessary by the master microcomputer. A test is made, at **802**, of whether the antenna retracted indication has been received from the slave microcomputer **414** on the bus **415**. If an antenna retracted indication is received, then the master microcomputer **404** sends a keypad disable command at **804**, to the slave microcomputer **414** on the bus **415**. The master microcomputer **404** then returns to its programmed routine of chores. If an antenna retracted indication is not received, at **802**, then a test is made of whether an antenna extended indication has been received from the slave microcomputer **414**, at **806**. If such an indication has been received by the master microcomputer **404**, then a command is sent to the slave microcomputer **414** on the bus **415** to enable the slave microcomputer **414** to again read any keypad button depressions and to send such information to the master microcomputer **404**. Upon completion of the enable command, the master microcomputer **404** returns to its routine chores.

The process followed by the slave microcomputer **414** in realizing the present invention in the preferred embodiment is shown in FIGS. **9**A and **9**B. The slave microcomputer **414** memorizes the state of the hookswitch **305** corresponding to whether the antenna is extended or retracted. The slave microcomputer **414** determines as part of its routine of chores, whether the hookswitch **305** has changed state by comparing the current state against the stored state at **902** and **904**. If the state is different, then a determination is made, at **906** whether the antenna is extended or retracted. If the antenna is determined to be extended, then an extended antenna command (off-hook) is transmitted to the master microcomputer at **908**. If the determination is made at **906** yields a retracted antenna, then a retracted antenna command (on-hook) is conveyed to the master microcomputer at **910**. In either case the master microcomputer **404** always maintains the antenna state in its associated storage. The slave microcomputer, as part of its routine of chores, checks for a keypad enable or keypad disable command received from the master microcomputer **404**. This determination is made at decision blocks **912** and **914**. A keypad enable command sets a keypad enable flag in the slave microcomputer **414** memory at **916**, while a keypad disable command clears the keypad enable flag at **918** before the process of FIGS. **9**A and **9**B resumes its normal background flow.

Further along the normal background process the slave microcomputer **414** reads the keypad enable flag, at **920**, and reads the row and column lines from the keypads in addition to the volume increase switch **207** and the volume decrease switch **209**, at **922**, to determine if any key or switch has been depressed, at **924**. If a key or switch has been depressed, then an identification of the key or switch depression is sent to the master microcomputer at **926**. The process of FIGS. **9**A and **9**B then returns to the normal slave microcomputer background functions at **926**. Thus, if the antenna is determined to be extended, then the keys of the keypad and the volume increase and decrease switches are read in conventional fashion. If the antenna is determined to be retracted then the keys of the keypad and volume increase and decrease switches are ignored.

The "on/off" key **508** is also exposed and prone to accidental actuation. In the preferred embodiment, the on/off key is placed among the matrix of keypad keys for aesthetic reasons. It is a desirable feature that once the power is turned on, the portable transceiver remains in a power-on mode and not be turned off due to a spurious on/off key depression when the antenna is retracted. Likewise, when the portable transceiver is turned off, it is equally desirable that the portable transceiver remain in the powered-off condition even though a spurious on/off key depression may occur when the antenna is retracted. Two processes enable this operation.

Depression of the on/off key is ignored when the antenna is retracted. Referring again to FIG. **4**, when a momentary depression of the on/off switch **508** occurs, a ground signal is applied to the on/off line at **412** into the power controller **410** of FIG. **4**. The ground signal is buffered by power controller **410** and applied to the master microcomputer **404** via line **414**. Upon receipt of this buffered on/off signal on line **414**, the master microcomputer **404** follows the process flow charted in FIG. **10**.

In FIG. **10**, the master microcomputer **404** and the rest of the associated microcomputer system undergoes a reset operation at **1002** and requests a system characterization (a definition of what peripherals exist on the bus) at **1004**. As part of the characterization process, the slave microcomputer **414** reports the state of the antenna. The current antenna state is then stored, at **1005**. The master microcomputer then determines if the antenna is extended, at **1006**. If this determination is positive, then the master microcomputer proceeds with its normal wake-up and house keeping routines. If the antenna is determined to be retracted at **1006**, then a check is made to determine if an external supply has been connected to the portable radiotelephone at **1008**. A similar circuitry sharing arrangement is further described in U.S. Pat. No. 5,029,233.

If an external supply is determined to exist at **1008**, then the master microcomputer **404** returns to its normal housekeeping routines. If the external supply is not connected, then a power turn-off routine is followed at **1010**. Power turn-off is accomplished by the master microcomputer **404** by storing its status and other essential parameters in memory before allowing the watchdog functions **406** of FIG. **4** to run out. A watch dog power function run out is communicated to the power controller **410** which subsequently turns off the portable radiotelephone.

Once the master microcomputer **404** has successfully powered up any on/off switch depressions are ignored so as long as the antenna is retracted. A determination of the signal sense on line **414** of FIG. **4** is made by the master microcomputer **404** at **1102** of FIG. **11**. If the sense is signal high, then the master microcomputer continues with its background routines. If the sense is low, then the master microcomputer reads the status of the antenna state in storage at **1114** and either proceeds with a turn off routine at **1116** if the antenna is extended or ignores a depression of the on/off

switch as a spurious depression if the antenna is retracted. Thus, a valid on/off command may be processed only if the antenna is extended.

The process followed by the master microcomputer **404** in realizing the present invention in the preferred embodiment **325** and **327** is shown in FIGS. **12**A and **12**B. The master microcomputer **404**, as part of its routine of chores, at **1202**, checks for an on-hook to off-hook transition at **1204**. If an on-hook to off-hook transition has not occurred then flow proceeds to determination block **1206** where a test is made to determine if an off-hook to on-hook transition has occurred. If none has occurred, then flow returns to the normal background functions at **1202**. If it is determined that an off-hook to on-hook transition has occurred at **1206** indicating that the antenna **213** is in the retracted position, then flow proceeds to determination block **1208** where a test is made to determine if a telephone call is presently in progress. If it is determined that a call is not presently in progress, then flow proceeds to **1210** where the voice recognition circuitry is disabled, the backlighting is inactivated, and the display is inactivated. Thus, if the antenna **213** is retracted while a call is not in progress, then the voice recognition circuitry, the backlighting, and the display are inactivated.

Optionally, the display may remain actuated for a period of six seconds before being deactivated by such an off-hook to on-hook transition. From **1210**, flow returns to the normal background functions at **1202**. If a determination is made that a call was in process, at **1208**, then flow proceeds to determination block **1212**. A test is made at **1212**, of whether the microphone mute function is on. If the microphone is muted, then flow proceeds to **1214** where the voice recognition circuitry is disabled. Thus, when the antenna **213** is retracted while a call is in progress and the microphone is muted, the voice recognition circuitry is disabled. Flow proceeds from block **1214** to **1202** where flow returns to normal background functions. If it is determined, at **1212**, that the microphone is not muted, then flow proceeds to block **1216** where a timer of 'n' milliseconds is started. This timer runs until it has either expired or the antenna is extended. After the counter is started, flow proceeds to determination block **1218** where a test is made to determine whether the timer has expired. If the timer has expired then the flow proceeds to block **1220** where the telephone call is terminated. Thus, if the antenna is retracted for longer than 'n' milliseconds while a call is in progress and the microphone is not muted, then the call is terminated. In the preferred embodiments, the timer duration 'n' is 1000 milliseconds.

The flow proceeds to determination block **1222** where a test is made of whether an on-hook to off-hook transition has occurred. If no on-hook to off-hook transition has occurred, then flow returns to determination block **1218**. Flow continues in the **1218**–**1222** loop until either the timer expires or an on-hook to off-hook transition occurs. If a determination is made, at **1222**, that an on-hook to off-hook transition has occurred prior to the timer expiring, then flow proceeds to determination block **1223**. A test is made, at **1223**, of whether the telephone is coupled to the hands-free vehicular adaptor circuit **450**. One such vehicular adaptor circuit which may be employed by the present invention is a S1747A available from Motorola, Inc. If the telephone is not coupled to the vehicular adaptor **450** then flow proceeds to a decision block **1224**, where a determination of whether the voice recognition circuit has been enabled. If the voice recognition circuit has been enabled, it is then disabled, at block **1225**, before the process returns to the normal background functions at **1202**. If the voice recognition circuit is not enabled at this time, then the process proceeds to block **1226** where a hookswitch flash signal is sent.

Optionally, a hookswitch flash signal may be sent if the "send" key on the keypad is depressed. Thus, if the portable radiotelephone is coupled to the hands free vehicular adaptor **450** and is engaged in a telephone call when the hands-free circuit of the vehicular adaptor is enabled, the momentary retraction and extension of the antenna (in less than 'n' msec.) deactivates the hands-free function and the portable radiotelephone reverts to the use of the internal microphone and speaker. Likewise, if the portable radiotelephone is coupled to the hands-free adaptor **450** and engaged in a telephone call with the hands-free circuit disabled, the momentary retraction and extension of the antenna results in the activation of the hands-free circuit. If the portable radiotelephone is not coupled to the hands-free vehicular adaptor **450** and is presently in a call with the microphone not muted where the antenna is momentarily retracted and then extended prior to the timer expiring, then either the voice recognition circuit is disabled or a hookswitch flash signal is sent. From **1226**, flow returns to the normal background functions at **1202**.

If a determination is made, at **1223**, that the telephone was in the hands-free vehicular adaptor, then the process flow continues to determination block **1228**. A test is made at **1228**, to determine whether the telephone is currently in the hands-free mode. If it is determined , at **1228**, that the telephone is not in the hands-free mode, then the process flow proceeds to block **1230** where the mode is set to the hands-free mode. In the hands-free mode, the internal microphone **420** and speaker **424** are inactivated and the external microphone **454** and external speaker **456** are active. Thus if the portable radiotelephone is in the hands-free vehicle adaptor **450** and is presently in a call with the microphone not muted while the antenna is momentarily retracted and then extended prior to the timer expiring but is not in the hands-free mode at the time, then the mode is changed from a private call with the radiotelephone's internal microphone and speaker to the hands-free mode using the external microphone and speaker.

From **1230**, flow returns to the normal background functions at **1202**. If it is determined, at **1228**, that the portable radiotelephone was in the hands-free mode then the flow proceeds to block **1232** where the mode is changed from the hands-free mode to a private call using the radiotelephone's internal microphone and speaker. Thus if the portable radiotelephone is in the hands-free vehicular adaptor **450** and is presently in a call with either microphone not muted while the antenna **213** is momentarily retracted and then extended prior to the timer expiring and the radiotelephone is in the hands-free mode at the time, then the mode is changed from the hands-free mode to that of a private call using the radiotelephone's internal microphone **420** and speaker **424**. From **1232**, flow returns to the normal background functions at **1202**.

If it is determined, at **1204**, that an on-hook to off-hook transition occurred then the flow proceeds to block **1234** where the voice recognition circuitry **432** is activated. The process then, at **1235**, activates the keypad backlighting illumination and the display **211** for a conventionally timed period of six seconds. Thus, if the master microcomputer **404** is performing normal background functions and an on-hook to off-hook transition occurs, then the voice recognition circuitry is activated, the keypad backlighting is activated, the display is activated. The flow continues to determination block **1236**. A test is made, at **1236**, to

determine whether the microphone mute function is on. If it is determined, at **1236**, that the microphone is muted, then flow proceeds to block **1238**, where the microphone is unmuted. Thus, if the microphone is in the muted state with the antenna **213** retracted, extending the antenna will unmute the microphone, from **1238** flow returns to the normal background functions **1202**.

If it is determined, at **1236**, that the microphone was not muted, then flow proceeds to determination block **1240**. A test is made, at **1240**, to determine whether the portable radiotelephone is currently ringing. If it is determined, at **1240**, that the portable radiotelephone is not ringing, indicating that there is no incoming call, then the process flow returns to the normal background functions at **1202**. If it is determined, at **1240**, that the radiotelephone is ringing, then the process flow proceeds to block **1242** where the incoming call is answered. Thus, if the portable radiotelephone is ringing while the antenna **213** is retracted an the antenna **213** is extended, the incoming call is answered. From **1242**, flow returns to the normal background functions at **1202**.

According to the present invention, the radiotelephone's transmit power is yet another predetermined operating mode that can be controlled responsive to the position of the antenna. The transmitter's power is adjusted responsive to the position of the antenna so that the radio can transmit RF signals at a higher power level while limiting the exposure of humans to energy radiated by the transmitter's antenna. Radiotelephones having adjustable transmit power responsive to the position of the antenna may or may not include the prior art flip element **101**. If the flip element **101** is not included as shown in FIG. **2**, the movable antenna may combine the adjustable transmit power control with other appropriate control functions described hereinabove.

FIG. **13** is a drawing showing the change in distance between the antenna **213** of the portable radiotelephone **200** and a user's head **1301** when the antenna is retracted and extended. The antenna **213** is located at a first predetermined distance D1 and a second predetermined distance D2 away from a portion of the body, particularly the head **1301**, of the user operating the radiotelephone **200** when the antenna is moved to the retracted position and extended position, respectively. The present invention may be used with any type of movable antenna and not the particular axial antenna shown and described herein.

For a given transmit power, the exposure of the user's head **1301** to the antenna's radiated energy decreases when the antenna **213** is extended and increases when the antenna is retracted primarily because of the change in distance between the antenna **213** and the user's head **1301** when the antenna **213** is moved. Since the exposure of the head to the antenna's radiated energy decreases when the antenna **213** is extended, the radio's transmit power is increased when the antenna **213** is extended. Conversely, since the exposure of the head **1301** to the antenna's radiated energy increases when the antenna is retracted, the radio's transmit power is reduced when the antenna is retracted. Thus, the transmitter's power is adjusted so that the radio can transmit RF signals at a high power level when the antenna is extended and at a low power level when the antenna is retracted to limit the exposure of humans to energy radiated by the transmitter's antenna in both the extended and retracted positions.

The high and low power levels at which the portable radiotelephone **200** transmits RF signals are defined as Classes in EIA INTERIM STANDARD, Cellular System Mobile Station—Land Station Compatibility Specification, IS-3-D, Mar. 1987. The EIA STANDARD defines Class **1** to be a high power radio (3 W), Class **2** to be a mid-range power radio (1.2 W) and Class **3** to be a low power radio (0.6 W). The Classes are primarily distinguished by the maximum power level at which the portable radiotelephone **200** can transmit RF signals. The present portable radiotelephone **200** is a Class **3**, low power, radiotelephone when the antenna is retracted and a Class **2**, mid-range power, radiotelephone when the antenna is extended.

The transmit power of the portable radiotelephone **200** may be adjustable or fixed in at least one of the retracted and extended positions. Table 2.1.2-1 of the EIA STANDARD defines seven power levels below the maximum power level at which the transmit power may be adjusted for each Class while the portable radiotelephone is transmitting. Thus, the transmit power of the portable radiotelephone **200** is adjustable within the Class **3** and Class **2** when the antenna is moved to the retracted and extended position, respectively. Other portable radiotelephones may operate as a portable cordless radiotelephone having a fixed transmit power when the antenna is retracted and as a portable cellular radiotelephone having an adjustable transmit power when the antenna is extended.

Returning now to FIG. **3A**, the antenna **213** of the radiotelephone **325** is shown to be movable between a first position **313** axially retracted substantially inside the radiotelephone **325** and a second position **314** axially extended substantially outside the radiotelephone **325**. The reed switch **305** and the magnet **301** provides means for detecting movement of the antenna between the retracted and extended positions.

Referring now to FIG. **4** and **5**, the transceiver **420** comprises means for transmitting an output signal from the antenna **213** and means for receiving an input signal from the antenna **213**. Means for transmitting includes conventional power amplifying means having gain. The slave microcomputer **414** in combination with the master microcomputer **404** (per FIG. **4**) provide controlling means for adjusting the gain of the power amplifier responsive to the detected movement of the antenna to adjust the radiotelephone's transmit power.

Thus, the radiotelephone advantageously provides means for transmitting from the antenna **213** an output signal having a first and a second output power level when the antenna is moved to the first and the second position, respectively. Stated from another perspective, the radio produces a first and a second transmit power responsive to the antenna being moved between the first and the second position, respectively.

The portable radiotelephone conventionally notifies a remote base station (not shown) of its Class at the beginning of transmission. The EIA STANDARD, per section 2.3.3, defines a digital representation of the Classes as a Station Class Mark. The Station Class Mark is sent to the base station from the portable unit as a four bit digital code via a control channel per section 2.7.1.1, Word A of the EIA STANDARD.

A complementary feature of the present invention enables the radiotelephone to also notify the base station of its Class not only at the beginning of transmission but also at any other time during transmission via a blank and burst control message on the voice channel. The movable antenna provides means for selecting to transmit the output signal at least one of a first and a second power level. The means for selecting comprises any user interface and need not be limited to the movable antenna as shown and described

herein. The base station is notified of the selected power level during the transmission of the output signal.

Means for notifying the base station of the change in Class during radiotelephone transmission is accomplished by sending the updated four bit Station Class Mark via the Order Confirmation Message as described in the EIA STANDARD section 2.7.2.1. Presently, nineteen bits are not used of which four are assigned to the updated Station Class Mark. Thus, while the radiotelephone is in a call, the base station is notified of the change in power level of the radiotelephone. This up to date power information allows the base station to control the adjustment of the transmit power within the new Class, as required, to improve the radiotelephone's transmit performance.

FIG. **14** is a flowchart depicting a change in the radiotelephone's transmit power responsive to the radiotelephone's antenna position. FIG. **14** accounts for the antenna being moved before a call is initiated and while a call is in process. The transmit routine at block **1401** is entered either when the user initiates a call (i.e. begins transmission) or when the user moves the antenna while in a call (i.e. during transmission). The radiotelephone determines whether the antenna is extended or retracted at block **1403**. The radiotelephone sets the maximum transmit power at 0.6 W corresponding to Class **3** at block **1407** when the antenna is retracted and at 1.2 W corresponding to Class **2** at block **1405** when the antenna is extended. If a call is determined to be in process at block **1408** (i.e. the transmitter already active), the radiotelephone bypasses block **1409** to notify the base station of the Class at block **1411**. Otherwise, if a call is determined not to be in process at block **1408** (i.e. the transmitter is inactive), the radiotelephone activates the transmitter at block **1409** and notifies the base station of the Class at block **1411**. After the base station is notified of the radiotelephone's Class at block **1411**, normal transmitter processing resumes at block **1413**.

What is claimed is:

1. A portable radiotelephone comprising:

an antenna element moveable between a stowed position and an unstowed position;

a detector for detecting the movement of the antenna element between the stowed and the unstowed position, wherein the movement of the antenna causes the detector to be in a first state when the antenna element is moved to the stowed position and causes the detector to be in a second state when the antenna element is moved to the unstowed position;

a transmitter for transmitting a signal at a first power level or a second power level, wherein the second power level is greater than the first power level; and

a controller, coupled to the detector and the transmitter, wherein the controller controls the transmitter to transmit the signal at the first power level when the detector is in the first state and controls the transmitter to transmit the signal at the second power level when the detector is in the second state.

2. A portable radiotelephone in accordance with claim **1** wherein:

the transmitter is operative to transmit the signal at a first power level within a first range of power levels and at a second power level within a second range of power levels, wherein a second maximum power level of the signal within the second range of power levels is greater than a first maximum power level of the signal within the first range of power levels; and

the controller controls the transmitter to transmit the signal at the first power level within the first range of power levels when the detector is in the first state and controls the transmitter to transmit the signal at the second power level within the second range of power levels when the detector is in the second state.

3. A portable radiotelephone in accordance with claim **2** wherein the power level of the signal is adjustable within at least one of the first and the second range of power levels.

4. A portable radiotelephone in accordance with claim **2** wherein the power level of the signal is fixed within at least one of the first and the second range of power levels.

5. A portable radiotelephone in accordance with claim **2** wherein the power level of the signal is fixed within the first range of power levels when the detector is in the first state and adjustable within the second range of power levels when the detector is in the second state.

6. A portable radiotelephone in accordance with claim **2** wherein the first and the second range of power levels of the transmitter further comprise Class **3**, low power levels, and Class **2**, mid-range power levels, respectively.

7. A portable radiotelephone in accordance with claim **2** wherein the controller notifies a base station via the transmitter that the transmitter is operable to transmit the signal at a power level within the first range of power levels and at a power level within the second range of power levels when the detector is in the first state and the second state, respectively.

8. A portable radiotelephone in accordance with claim **7** wherein the notification occurs during a telephone call.

9. A portable radiotelephone in accordance with claim **1** further comprising:

a housing including the detector, the transmitter and the controller;

wherein the antenna element is axially retracted substantially inside the housing when the antenna element is moved to the stowed position and axially extended substantially outside the housing when the antenna element is moved to the unstowed position.

10. A portable radiotelephone comprising:

a transmitter for transmitting a signal at a power level within one of a plurality of predetermined ranges of power levels, wherein each of the plurality of predetermined ranges of power levels is indicative of a maximum power level of the signal therein;

means for selecting one of the plurality of predetermined ranges of power levels for transmitting the signal; and

means for notifying a base station during a telephone call that the transmitter is operable to transmit the signal at the selected one of the plurality of predetermined ranges of power levels.

11. A portable radiotelephone in accordance with claim **10** wherein the means for selecting further comprises antenna means including an antenna element moveable between a stowed and an unstowed position, wherein a first and a second range of power levels of the plurality of predetermined ranges of power levels are selected when the antenna element is moved to the stowed and the unstowed position, respectively.

12. A method of operating a portable radiotelephone, the portable radiotelephone including an antenna element moveable between a stowed position and an unstowed position and including a transmitter for transmitting a signal at a first power level or a second power level, wherein the second power level is greater than the first power level, the method comprising the steps of:

detecting the movement of the antenna element between the stowed and the unstowed position, wherein the

movement of the antenna causes the detector to be in a first state when the antenna element is moved to the stowed position and causes the detector to be in a second state when the antenna element is moved to the unstowed position; and

controlling the transmitter to transmit the signal at the first power level when the detector is in the first state and controls the transmitter to transmit the signal at the second power level when the detector is in the second state.

13. A method in accordance with claim **12** wherein the step of transmitting further comprises the step of

adjusting the power level of the signal within at least one of the first and the second range of power levels.

14. A method in accordance with claim **12** wherein the step of transmitting further comprises the step of

fixing the power level of the signal within at least one of the first and the second range of power levels.

15. A method in accordance with claim **12** further comprising the step of

notifying a base station that the transmitter is operable to transmit the signal at the power level within the first and the second range of power levels when the antenna element is moved to the stowed and the unstowed position, respectively.

16. A method in accordance with claim **12** wherein the step of

notifying occurs during a telephone call.

17. A method of operating a portable radiotelephone comprising the steps of:

transmitting a signal at a power level within one of a plurality of predetermined ranges of power levels, wherein each of the plurality of predetermined ranges of power levels is indicative of a maximum power level of the signal therein;

selecting one of the plurality of predetermined ranges of power levels for transmitting the signal; and

notifying a base station during a telephone call that the signal is operable to be transmitted at the selected one of the plurality of predetermined ranges of power levels.

18. A method in accordance with claim **17** wherein the step of selecting further comprises the step of detecting movement of an antenna element of antenna means between a stowed and an unstowed position, wherein a first and a second range of power levels of the plurality of predetermined ranges of power levels are selected when the antenna element is moved to the stowed and the unstowed position, respectively.

19. A portable communication device comprising:

an antenna moveable between a stowed position and an unstowed position;

a detector for detecting the movement of the antenna between the stowed and the unstowed position;

a transmitter for transmitting a signal at one of a first power level and a second power level within at least one predetermined range of power levels, wherein the second power level is greater than the first power level within the at least one predetermined range of power levels; and

a controller, coupled to the detector and the transmitter, for controlling the transmitter to transmit the signal at the first power level when the detector detects the antenna to be moved to the stowed position and for controlling the transmitter to transmit the signal at the second power level when the detector detects the antenna to be moved to the unstowed position.

20. A portable radiotelephone comprising:

an antenna moveable between a stowed position and an unstowed position;

a detector for detecting when the antenna is in the stowed position and the unstowed position;

a transmitter for transmitting a signal at one of a plurality of predetermined power steps up to a maximum power step, wherein the maximum power step is a first maximum power step when the detector detects that the antenna is in the stowed position, and wherein the maximum power step is a second maximum power step, higher than the first maximum power step, when the detector detects that the antenna is in the unstowed position; and

a controller for controlling the transmitter to transmit the signal at one of the plurality of predetermined power steps up to the maximum power step.

21. A method of operating a portable radiotelephone comprising the steps of:

detecting movement of an antenna between a stowed position and an unstowed position; and

transmitting a signal at one of a plurality of predetermined power steps up to a maximum power step, wherein the maximum power step is a first maximum power step when the detector detects that the antenna is in the stowed position, and wherein the maximum power step is a second maximum power step, higher than the first maximum power step, when the detector detects that the antenna is in the unstowed position.

22. A portable radiotelephone comprising:

a housing having a microphone and a speaker and adapted to be positioned against a user's head to permit a user to speak into the microphone and listen from the earpiece speaker;

an antenna moveable between a stowed position and an unstowed position relative to the housing, wherein the antenna is positioned closer to the user's head when the antenna is in the stowed position than when the antenna is in the unstowed position;

a transmitter for transmitting a signal at one of a plurality of predetermined power levels up to a maximum power level, wherein the maximum power level is lower when the antenna is in the stowed position than when the antenna is in the unstowed position; and

a controller for controlling the transmitter to transmit the signal at one of the plurality of predetermined power levels up to the maximum power level.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,815,820
DATED : October 15, 1998
INVENTOR(S) : Kiem

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

In column 2 between lines 29 and 30,
add the section title -- SUMMARY OF THE INVENTION --

Claim 13
In column 21, on line 12 please change "of" to -- of: --

Claim 14
In column 21, on line 16 please change "of" to -- of: --

Claim 15
In column 21, on line 20 please change "of" to -- of: --

Claim 16
In column 21, on line 26 please change "claim **12**" to
-- claim **15** --

Signed and Sealed this

Twenty-fifth Day of April, 2000

Attest:

Q. TODD DICKINSON

Attesting Officer

Director of Patents and Trademarks